ILLUMINATING ENGINEERING

JUNE 1956

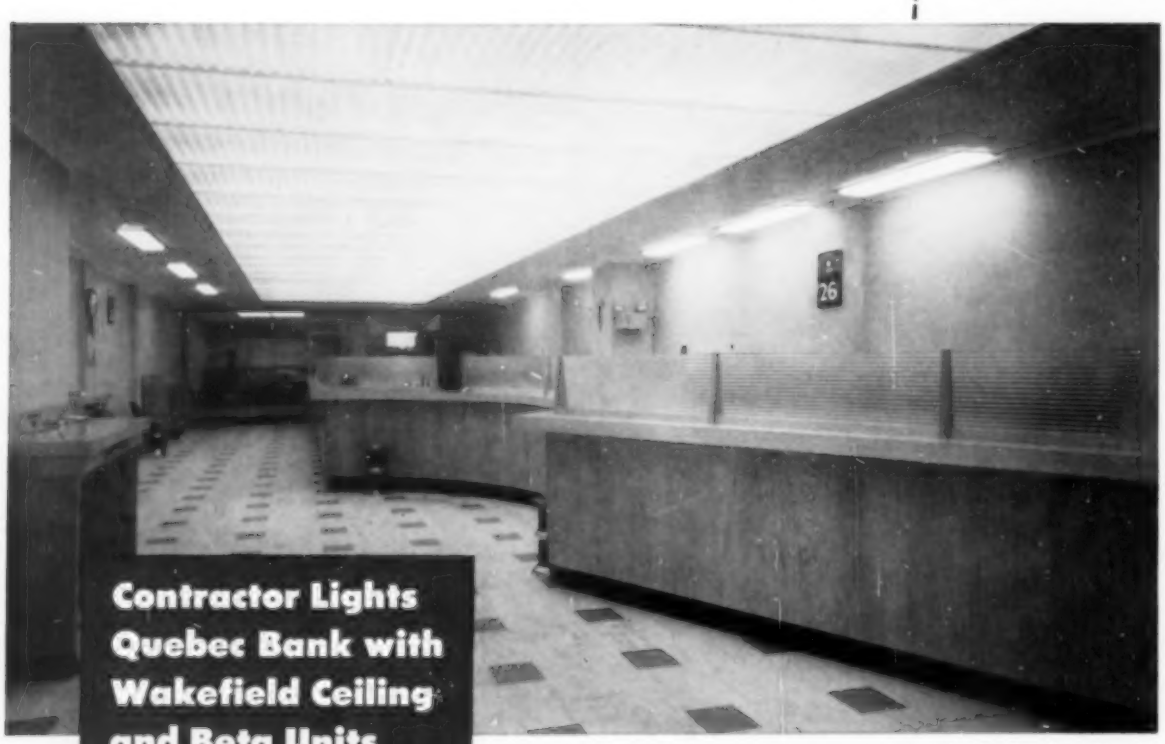
Featuring

Office Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

WAKEFIELD CEILING

Another Installation



Contractor Lights Quebec Bank with Wakefield Ceiling and Beta Units

Caisse Populaire Notre Dame de Lourdes de Verdun, Verdun, Que.

Old store is transformed into modern bank interior with over-all lighting provided by a Wakefield Ceiling and perimeter lighting furnished by Wakefield recessed Beta units.

Electrical contractors are becoming increasingly aware of the adaptability of Wakefield lighting equipment to various lighting situations. Here for example, the general contractor and the electrical contractor put their heads together and transformed an old store into a modern, attractive, functional bank interior, using equipment from the varied Wakefield line to furnish the illumination. You would never know that the old ceiling, now completely hidden, was of wood construction with 12″ x 2″ wood joists running the length of the building, on 16″ spacing, with steel beams running crosswise, cutting up channel runs. The electrical contractor reports that despite these difficulties, the mechanical and electrical features of the Wakefield Ceiling made installation relatively simple.

Electrical Contractor:
Verdun Armature Work., Verdun, Quebec

General Contractor:
Fernand Asselin, Verdun, Quebec

Over-all lighting: a Wakefield Ceiling of corrugated plastic suspended on fusion strips. Initial footcandles 75.

Supplementary lighting: eight 1′x4′ Beta units with Rigid-Arch plastic diffusers (2 40-W Rapid Start lamps) recessed in metal type acoustical pan perimeter.

If you have not already obtained Wakefield Catalog 55 containing essential data on this and other Wakefield lighting equipment, you should write for your copy at once.

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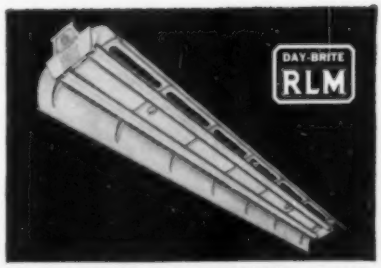
Lighting by DECIDEDLY BETTER DAY-BRITE Lighting Fixtures makes the big difference



Day-Brite CFI-10, with 10% upward lighting component

Day-Brite CFI-25, with 25% upward lighting component

Typical Day-Brite CFI (Comfort For Industry) installation

Doing the job right

is so dependent on lighting it right. And good lighting makes the big difference in seeing and doing—relieves eye strain and fatigue, helps meet close tolerances, reduces spoilage, improves worker safety and morale. That's why industry is rapidly adopting new Day-Brite CFI (*Comfort For Industry*) fixtures with slotted reflector units which throw the light upward as well as down on the work . . . Before you decide on any phase of lighting, consult your Day-Brite representative. You'll find him in your classified phone directory. Or, send for special CFI industry-lighting literature.

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By introducing slotted openings in the reflector tops of Day-Brite CFI (Comfort For Industry) fixtures, a portion of the light is directed upwards. This provides two advantages: (1) Longer periods of maintained illumination are assured because natural updraft ventilation keeps reflectors cleaner. This means extra light at no extra cost. (2) Harsh ceiling contrasts are washed out; eye fatigue and discomfort are reduced. Result: greater work accuracy, greater safety, less spoilage, improved production.

Nation's largest manufacturer of commercial and industrial lighting equipment

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*—Certified to by John Powel, CPA, Bridgeport, Conn.

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

June
1956

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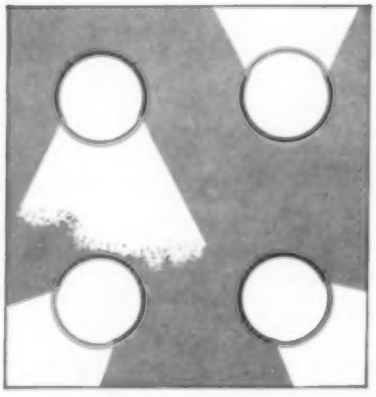
NEW Fluorescent Lamp *with Internal Reflector*



Single-pin-type lamps are extremely flexible! The lamp may be turned in any direction so that the light is directed where it is wanted.

THIS new Directional Reflector Fluorescent Lamp is the result of research on the part of Sylvania lamp engineers to give the public better lighting in industrial and commercial applications. An internal reflector coating, covering more than half the circumference of the tube, is applied between the glass and the standard fluorescent phosphor.

More relative light! The Sylvania Directional Reflector Fluorescent Lamp increases the relative light through the aperture by as much as 60 per cent brightness.

Under service installations where dust and dirt are present, this lamp will give the user a significant increase in more useful light. It is less affected by deposits of "light-stealing" dust and dirt on the top surface of the lamp.

Many advantages! Sylvania's Directional Reflector Fluorescent Lamp may be mounted without reflectors in installations with ceilings of poor reflectance. It will step up the light output of fixture reflectors that are deteriorated by age. It saves on lamp cleaning and maintenance costs, gives increased lumen hours in supermarkets and commercial establishments using bare single-pin fluorescent lamps.

The directional lamps in production are the 48-inch and 96-inch, cool white, single-pin sizes.

Our commercial engineering department will be glad to help you with your special application or installation problems. For complete technical data write directly to:

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The Problem of the Warehouse Ceiling...

To solve the problem of creating modern, low-ceiling office facilities from high-ceiling loft space in this Chicago warehouse, General Mills' engineer, Derril Blevins, chose the Curtis Light & Sound System. The fluorescent lighting system provides lighting of 45 footcandle average illumination with a visual comfort index of 90+. The sound system gives excellent acoustical results without costly installation and also hides the jungle of pipes, wires and sprinkling apparatus creating a modern low-ceiling effect. Even more important is the savings in time and money this Curtis system will continually provide as it permits servicing, maintenance and installation of additional pipe, conduit, ducts, etc. without either the loss of time or replacement cost a regular suspended ceiling would require.

Shown here is an actual "before" photograph of the warehouse before it was transformed by Curtis Light and Sound to the modern, attractive offices above. This is another of many outstanding installation problems throughout America that have been solved by the application of Curtis engineered lighting. To receive a copy of the illustrated brochure on the Curtis Light and Sound System, fill in the coupon and mail it today. No obligation of course.

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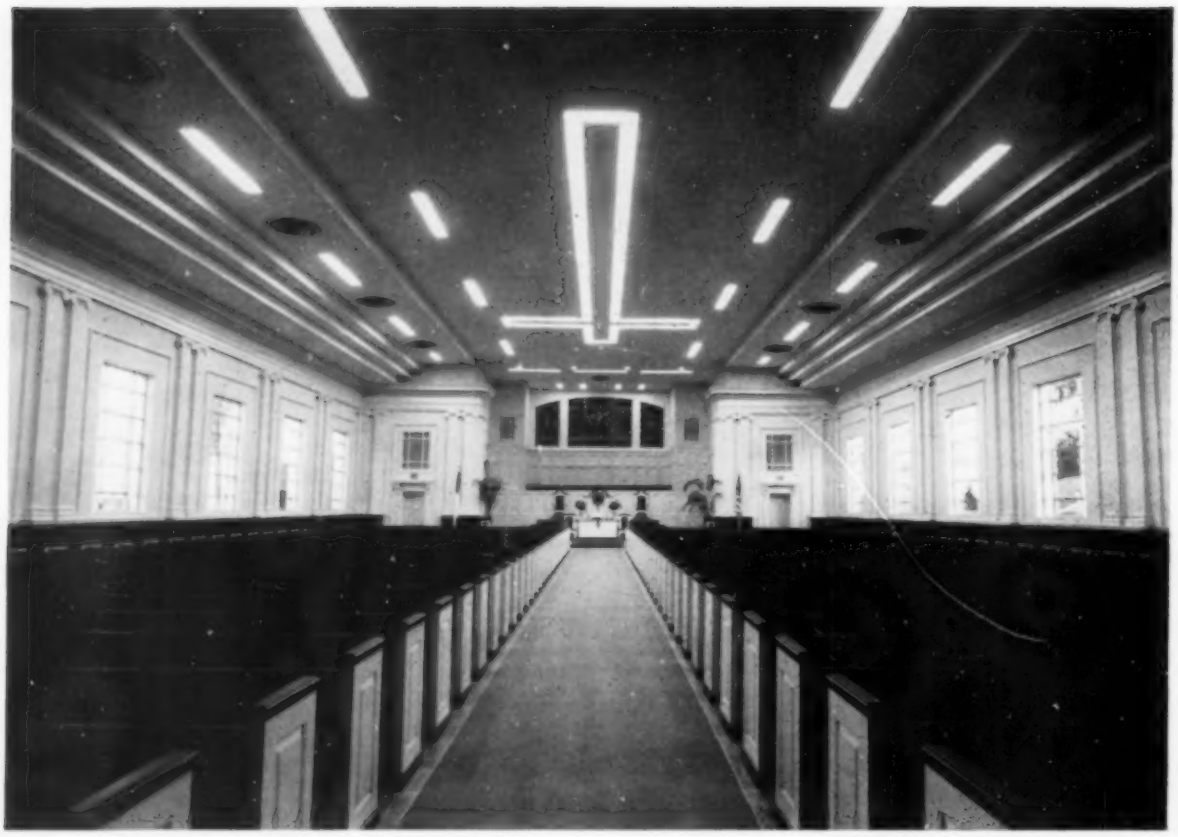

Flexibility, Imagination and a Spiritual Quality in this Church Installation – by **LITECONTROL**

This lighting installation at the First Methodist Church, Sarasota, Florida exemplifies what can be done with *adaptations* of standard Litecontrol fixtures. We are proud of the ingenuity expressed in this job but more important, it shows how Litecontrol fixtures, either standard or modified, can be made to fit into almost any interior functionally and appropriately.

While incandescent lens box lighting was indicated, the Church Committee preferred a different type of system. Responding to the challenge, our District Sales Engineer, Mr. Frank Moos, of Tampa, Florida, in collaboration with the architect and engineer, visualized the symbolic and functional arrangement shown, with recessed fluorescent troffers in the shape of a cross.

All troffers have hinged covers — they may be relamped from a catwalk above the ceiling. Corning Albalite #66 glass diffuses the light. This glass is cloth bound on the outside edges to prevent any rattling or vibration from organ reverberations. With cross pieces omitted along the rows, except at the corners, the glass appears as a continuous piece. Four foot, Rapid Start lamps are used for ease in handling. They are wired on two and three circuits, to provide variable intensity.

If cost control is a major factor in a lighting installation, standard Litecontrol fixtures will save money — and do a quality job. Yes, and if modification of standard fixtures is required to solve a special problem, you can rely on Litecontrol for the touch of imagination the situation requires.

INSTALLATION: First Methodist Church, Sarasota, Florida

ARCHITECT: Garry A. Boyle, Tampa, Florida

ENGINEER: Nathan A. Grout, Tampa, Florida

CEILING HEIGHT: 25 feet

INTERIOR FINISHES: Ceiling off-white acoustic tile and plaster; pews dark mahogany; floors pale green carpet.

FIXTURES: In cross, 38-two-lamp Rapid Start troffers, with hinged covers for top service, Albalite #66 glass panels, with lamps wired on two circuits. Remainder of fixtures are 21-six-lamp 40 W Rapid Start 8 foot troffers, as above and 18-three-lamp 40 W Rapid Start 4 foot troffers. These are all wired on three circuits.

INTENSITY: All lamps on, average 25 footcandles maintained.

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Fixtures

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LITECONTROL CORPORATION

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DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Recommended Practice For Office Lighting

Prepared by the Office Lighting Committee
of the Illuminating Engineering Society

Foreword

The Illuminating Engineering Society published its first official recommendation for office lighting in 1917 in a report entitled "Code of Lighting Factories, Mills and Other Work Places." This code was revised in 1921 and again in 1930, each revision approved by the American Standards Association. In 1942 a new "Recommended Practice of Office Lighting was published, the first such I.E.S. publication devoted solely to office lighting with no industrial lighting included. That was revised in 1947. This current Recommended Practice represents six years of intensive work by members of the Committee listed below, as well as the thinking of representatives from the I.E.S. School Lighting Committee, the American Institute of Architects, and the National Council for Schoolhouse Construction (who are working on a revision of the 1948 "American Standard Practice for School Lighting") with whom the Office Lighting Committee worked closely to assure that recommendations in the two reports would not conflict.

I.E.S. Committee on Office Lighting

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1. General

The purpose of lighting is to provide efficient and comfortable seeing as an aid to office operation and the conservation of vision. It is important, therefore, to analyze the controllable factors which contribute to seeing: the *task*, the *lighting*, and the *environment*. While in practice these factors are closely interrelated, they are, for practical considerations, individually treated in this publication.

2. Office Tasks

2.1 — *General*

2.1.1 — In modern office operations, the eyes are used at close range for severe visual tasks such as reading duplicated material, handwriting, penciled stenographic notes, typing and fine print. The visibility of such work is often poor and more attention should be devoted to its improvement.

2.1.2 — The visibility of the details of a task or object is determined by its *size, contrast* with background, *brightness,** and *time* of viewing. Each factor is sufficiently dependent upon the magnitude of the others that a deficiency in one, within limits, may be compensated by augmenting one or more of the others. Only the factors of *size* and *contrast* are inherent in the task itself.

2.2 — *Size*

2.2.1 — Both printing and writing vary considerably in size. Type sizes in general use range from 6-point to 12-point type. As size increases, visibility increases, and, up to a certain point, readability improves and seeing becomes easier.

2.2.2 — The use of 6-point type is not desirable for continuous reading even by persons with normal vision.

2.2.3 — Eight-point type may be regarded as the minimum size tolerable if visibility and ease of seeing are of any consequence.

2.2.4 — A more reasonable type size and, fortunately, one finding ever-increasing use for prolonged or continuous reading is this 10-point size.

2.2.5 — Studies indicate the desirability of 12-point type size for continuous reading over long periods of time.

2.3 — *Contrast*

2.3.1 — Each critical detail of a seeing task must differ in brightness or in color from the surrounding background to be visible. Visibility is a maximum when the brightness contrast (and color contrast if present*) of details with the background is greatest.

To illustrate conditions encountered in most office seeing tasks, the printing in this section has been shaded from a light gray at the left to a solid black at the right. The left is representative of the poor quality of characters resulting from penciled longhand and shorthand notes, the use of worn machine and typewriter ribbons, poor carbon paper, and many duplicating methods. Care should be taken to use darker inks, ribbons, carbons and pencils which will produce results as represented by the quality printing at the right.

2.3.2 — Visibility may also be reduced with lower reflectance of the background. To illustrate this factor, the background of this paragraph has been shaded. Most office tasks, generally considered as black print on white paper, actually consist of shades of gray against degrees of lighter gray. Care should be taken to avoid the use of thin papers which are likely to lack opacity and have a low reflectance. Light tints of color are sufficient for the necessary identification of forms and need not appreciably reduce the reflectance of paper as do dark and highly saturated colors. Identification can also be obtained through the use of a colored band across the top of white paper.

Approved by the Council of the Illuminating Engineering Society, October 1955.

*See Appendix A for lighting definitions and nomenclature.

*Study "Influence of Color Contrast on Visual Acuity," OSRD#4541, November 1, 1944.

2.4 — *Readability*

Almost all office tasks involve some aspect of reading. Readability depends upon size and contrast plus other attributes such as type face of printing or style of writing, length of lines, spacing between lines and width of margins. Similarly, individual rules, lines and guides on various office forms will have certain degrees of visibility, but the overall readability can vary considerably, depending upon the coordination of the various elements.

3. Influence of Lighting on Seeing

3.1 — *General*

(a) Light is needed for seeing and the amount required for good seeing is greater than that required for mere discernment. The *brightness* resulting from the amount of light on a task can be controlled more readily and extensively than can the other factors of seeing—size, contrast and time. Brightness is therefore used to compensate for deficiencies in the other factors.

(b) It is essential that the application of light conform with certain fundamentals which contribute to comfortable seeing. These are briefly described as the quantity and quality of illumination. Quantity is important since only limited improvements in tasks can be expected in office work. Quality is essential to the creation of a comfortable environment and visual efficiency.

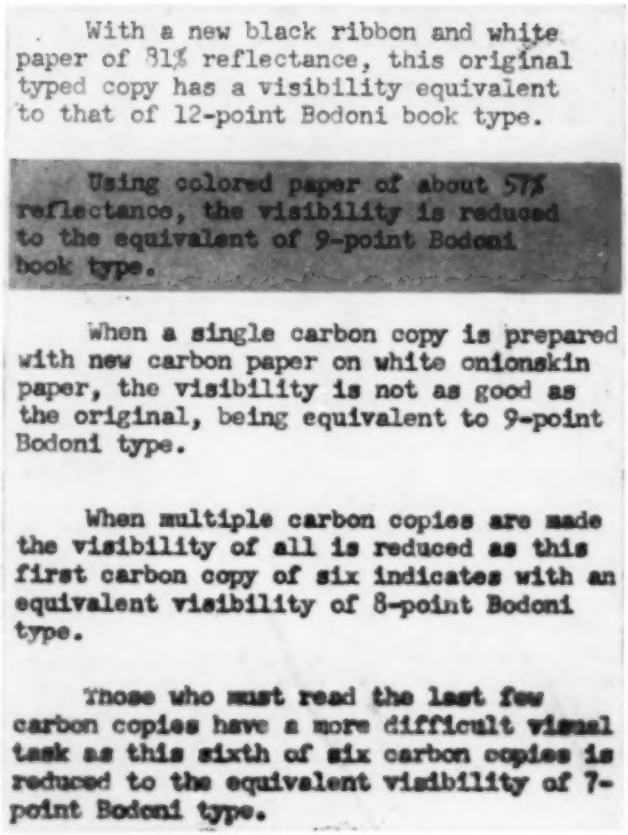

With a new black ribbon and white paper of 81% reflectance, this original typed copy has a visibility equivalent to that of 12-point Bodoni book type.
Using colored paper of about 57% reflectance, the visibility is reduced to the equivalent of 9-point Bodoni book type.
When a single carbon copy is prepared with new carbon paper on white onionskin paper, the visibility is not as good as the original, being equivalent to 9-point Bodoni type.
When multiple carbon copies are made the visibility of all is reduced as this first carbon copy of six indicates with an equivalent visibility of 8-point Bodoni type.
Those who must read the last few carbon copies have a more difficult visual task as this sixth of six carbon copies is reduced to the equivalent visibility of 7-point Bodoni type.

Figure 1. Even with the best of office materials and equipment, visibility varies among similar visual tasks. These samples were typed on an electric typewriter on which the key pressure was increased to compensate for multiple copies being made. A new black ribbon and new carbon paper of good quality were used, yet the variation in visibility is apparent from inspection.

3.2 — *Quantity of Illumination*

(a) The amount of light necessary for *most* efficient performance of office tasks is greater than is practicable today with even the most effective sources and the most effective lighting systems.* The lighting recommendations in Table I are based on the relative characteristics of the visual tasks and the practical performance requirements. The values are commensurate with the difficulty of the various seeing tasks and are higher for such work as is encountered in drafting, designing, bookkeeping and office machine operations than for the more casual or intermittent tasks. The former involve prolonged work periods with tasks of fine detail and poor contrast.

(b) The illumination values given in Table I should be maintained in actual service, on the work or in the space in which the given activity is carried on. To assure any maintained value of lighting, the *initial* value must be higher. A detailed discussion of maintenance is presented on page 443.

*Minutes of Light and Vision Conference held at the University of Michigan, June 8-9, 1953.

3.3 — *Quality of Illumination*

There should be no compromise with quality in office lighting because it is this element of the installation that determines the degree of seeing comfort that will prevail. The factors involved in lighting quality are many and complex, involving considerations of brightness, brightness ratios, light distribution, diffusion and color. Installations extremely deficient in lighting quality are easily recognized as glaring, uncomfortable and harmful. However, more moderate deficiencies are not readily detected although the cumulative effect of even slightly glaring conditions can result in loss of seeing efficiency and in undue fatigue.

3.3.1 — *Glare* — If anywhere within the visual field or fields viewed by an office worker in the course of a day's work, there are brightness conditions that reduce visibility — that cause visual discomfort — or that are visually annoying — they are categorically described as glaring. For systematic analysis, those in the field of view that are directly associated with the source of lighting and its immediate surroundings are classified as causing *direct glare*. Those directly associated with the visual tasks and their immediate surroundings are considered as contributing to *reflected glare*.

3.3.2 — *Direct Glare* — **(a)** Unshaded windows are a frequent cause of direct glare. They often permit direct view of the sun, bright portions of the sky, and the brightness of adjacent buildings. These often constitute large areas of very high brightness in the usual

fields of view. The condition may be controlled by employing shade, blind, louver or baffle systems on the windows. Current practices in the design of fenestration are described in Section 5.1.

(b) Luminaires which are too bright for the environment in which they are located produce direct glare. The eyes are quite susceptible to glare in the zone from the line of sight, which seldom is higher than horizontal, to about 45 degrees above (Fig. 2).

(c) Progress has been made in quantitatively evaluating the comfort or discomfort aspects of direct glare. Glare is reduced and seeing is improved by:

(1) *Decreasing the brightness* of the light sources and lighting equipment.

(2) *Diminishing the area* of potentially glaring high brightnesses.

(3) *Increasing the angle* between the glare source and line of sight.

(4) *Brightening the surroundings* against which the glare source is seen, but not increasing the surround brightness excessively to a point where the surround becomes a glare source (*e.g.*, an overly bright ceiling with an indirect lighting installation).

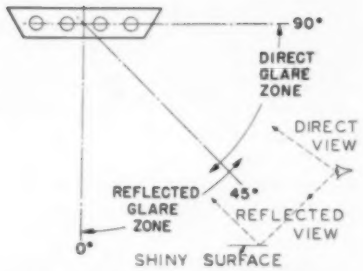


Figure 2. The direct and reflected glare zones are generally defined as shown by the above diagram. It should be noted that there is no sharp line of demarcation between these zones at 45 degrees.

(d) Although luminaire brightnesses have generally been specified, measured, and reported as *maximum* brightnesses (the brightest square inch at any given angle), investigations indicate that *average* brightness is a more pertinent criterion to use. The average brightness at any angle is determined when the candlepower* at that angle is divided by the projected area (in square inches) of all light generating and controlling elements of the luminaire that would be seen at that angle.** Air space containing no light generating or controlling elements should not be included as part of the area. High reflectance (exterior) opaque side panels of luminaires having at least 15 per cent of their total output in the 110-140 degree zone may be included as part of the projected area since, in practice, these side panels will be illuminated by light reflected from the ceiling to a brightness ap-

*Must be determined by actual measurement at the specific angle or picked from an accurate distribution curve drawn to a large scale.
**This brightness will be in candles per square inch and may be converted to footlamberts by multiplying by 452.

TABLE I.—Recommended Illumination Levels.

These recommendations are commensurate with the difficulty of the various groups of seeing tasks and the current general cost of lighting.

Higher values than those given are desirable when practicable and will under proper environmental conditions result in more efficient visual performance.

The values should be *maintained* in service through proper cleaning of lighting equipment, replacement of depreciated or failed lamps, and maintenance of room surfaces. Initial values will have to be greater by a percentage sufficient to compensate for the depreciation expected as outlined on page 443.

The recommended illumination should be provided on the work surface. Most office tasks are on a horizontal work plane but many seeing tasks are on vertical or nearly vertical surfaces. Illumination calculations generally determine the average horizontal level on the work plane; the vertical illumination will be in the order of ⅓ to ½ the horizontal work plane illumination level. Typical office seeing tasks which may be on other than horizontal surfaces are indicated by a single asterisk in the Table below.

	Footcandles — Current Recommended Practice on Work Surface
Difficult Seeing Tasks	50
Involving:	
(a) Discrimination of fine details such as 6-8 point type	
(b) Poor contrast	
(c) Long periods of time	
Such as:	
Auditing, Accounting, and Tabulating	
Business Machine Operation	
Bookkeeping	
*Drafting	
Designing	
*Transcribing from pencil notes or poor reproduction	
Ordinary Seeing Tasks	30
Involving:	
(a) Discrimination of moderately fine detail such as 8-12 point type	
(b) Better than average contrast	
(c) Intermittent periods of time	
Such as:	
Office Work except for work coming under "Difficult Seeing Tasks" above	
Conferring or Interviewing where reading or reference to seeing tasks of some severity is involved	
*Active Filing	
Mail Room Work	
Reception Room Tasks (on tasks)	
Casual Seeing Tasks	10**
Such as found in:	
Inactive File Rooms	
Discussion and conversational areas where no reading is involved	
Stairways and escalators	
Washrooms, and other service areas	
Elevators	
Hallways and Corridors	
Passageways	

*Likely to be on vertical or nearly vertical surface.
**Or 20 per cent of illumination in adjacent areas, whichever is greater.

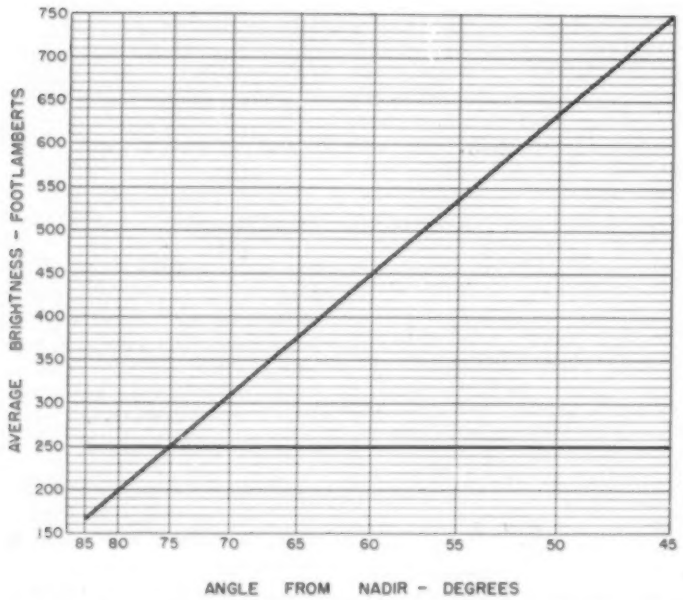


Figure 3. Direct glare zone limiting curves. Direct glare should not be a problem in 50-footcandle fluorescent lighting installations if ceiling and wall reflectances comply with Table III and if the luminaires used have crosswise and endwise brightness distributions which fall entirely below any straight line drawn through 250 footlamberts at 75 degrees lying between the above two limiting curves.

proximating that of a dense diffusing side panel. End panels of luminaires must not be included in projected area since luminaires are frequently installed end to end, thus eliminating the end panel for most of the units within the line of vision.

(e) Direct glare should not be a problem in 50 footcandle* fluorescent lighting installations (1) if ceiling and wall reflectances comply with Table III and (2) if the luminaires used have crosswise and endwise brightness distributions within the limits established in Fig. 3. The brightness distribution of the luminaire should be determined by plotting the average brightness at 10 degree angular intervals from 45 to 85 degrees. Table II gives brightness distributions for several typical limiting curves and may be used instead of Fig. 3 if preferred.

(f) The use of *average* brightness as the primary criterion for direct glare is based upon the assumption that office workers seldom raise their line of sight above horizontal. If the eyes are directed at the luminaires themselves, the effect of non-uniformity in their brightness distribution is more evident. Furthermore, marked non-uniformity may prove distracting. To prevent this, there should be a limit of maximum to average brightness. The ratio should be checked at each angle where the maximum brightness occurs in the 45-60, 60-75, and 75-87 degree zones. Brightnesses at angles greater than 87 degrees are not in view, even in the largest rooms. This ratio of maximum to average brightness preferably should be not more than 3 to 1, and in no case should it exceed 5 to 1, nor should the maximum brightness for a given angle ever be more than three times the average brightness shown for that angle on the sloping line of Fig. 3. The maximum brightness shall be the brightest square inch (square or circular).

(g) It is evident from (e) (2) above that luminaire brightness limitations are more stringent for large luminaires and large offices than for small ones. The limitations suggested in paragraph (e) are based upon large luminaires such as fluorescent luminaires in large offices. Because higher brightnesses are permissible for luminaires of smaller projected area, incandescent luminaires which commonly have about one-quarter the area of extended light source luminaires may have double the brightnesses indicated in paragraph (e). It is recognized that in small offices the brightness at the highest angles may not be significant* and the brightness limitations for these angles could, therefore, be disregarded without impairing seeing comfort. Since many buildings includes areas of mixed size or areas which are subject to change in size and, since most users would prefer to standardize on one luminaire type for all of their office areas, it is suggested than the complete brightness limitations of paragraphs (e) and (f) be used for all offices.

3.3.3—*Reflected Glare*—**(a)** Reflected glare may occur within the visual task itself or in the area immediately surrounding the task. It occurs when shiny surfaces reflect images of bright sources of illumination toward the eye. Such reflections in the task itself veil the detail and reduce visibility. Source reflections in shiny surfaces immediately adjacent to the task can be distracting, uncomfortable, and can reduce ability to see.

*Also generally applicable to 30-70 footcandle installations.

*The highest significant angle may be determined by making a cross-sectional sketch of the office with an occupant seated (eye level 4 feet above floor) in the least favorable location (at one end of room) viewing the most remotely located luminaire drawn in at its proposed mounting height and location.

TABLE II.

Any luminaire whose average brightness at each of the angles in the table below does not exceed the brightnesses in any single column of the table will comply with the intent of the limitations described in paragraph 3.3.2 (e).

Angle	Average Brightness (Footlamberts)								
85°	250	240	230	220	210	200	190	180	165
75°	250	250	250	250	250	250	250	250	250
65°	250	265	280	295	310	325	340	355	375
55°	250	285	315	350	385	415	450	480	535
45°	250	310	365	420	480	540	600	660	750

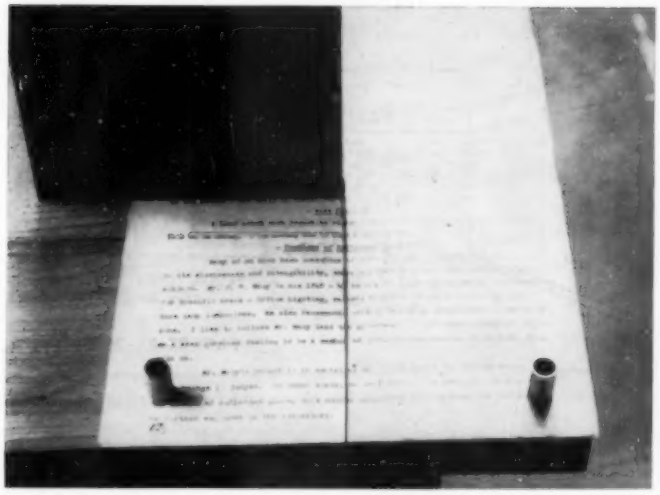


Figure 4. The left hand portion of this typical office task is so illuminated that there is no reflected glare, while the right hand portion is so lighted that maximum reflected glare from a medium brightness source occurs. The reduction in visibility resulting from the reflected glare condition is obvious.

(b) The bright source which is reflected may be either the fenestration, the luminaire, or both. In any case, the area of concern is the zone extending from vertical to approximately 45 degrees from vertical (nadir) although there is actually no sharp cutoff of the reflected glare zone at 45 degrees. At angles above 45 degrees from nadir the relative positions of the source, horizontal task, surround, and the eye are such that reflections will usually be directed below eye level.

(c) The main controlling factors related to reflected glare are:

(1) Degree of specularity (shininess) of task and surround.
(2) Reflectances of task and surround.
(3) Direction of light reflected from the task and adjacent area.
(4) Brightness of the light source.
(5) Amount of illumination contributed by the glare source as compared with the total illumination on the task and adjacent area.

(d) All of these factors should be controlled insofar as is practicable to provide the best seeing conditions at the task. To this end the following recommendations should be observed.

(1) The task and its surround should be matte (non-glossy). Matte surfaces such as good office bond paper, light-colored matte desk tops, satin or wrinkle-finished furniture and business machines disperse reflected glare to a large degree. Glossy printing inks and pencil lines, however, remain a difficult problem, for the reflection of bright areas in printed or written characters or areas materially reduce the visibility of the characters by reducing their brightness contrast with the background. In fact, this veiling effect may be more serious than reflections from glossy papers. It is, therefore, recommended that low gloss inks be used and specified in preference to pencil work.

(2) By using materials having a high reflectance for the task and the surround, reflected glare may be made less noticeable, but the reflectance of the surround should not exceed that of the task. Bright specular reflections stand out against dark finishes (Fig. 5) but virtually disappear in high reflectance surfaces (Fig. 6).

(3) Locate work surfaces with respect to the fenestration and electric light sources so that the image of the source is reflected away from the observer's

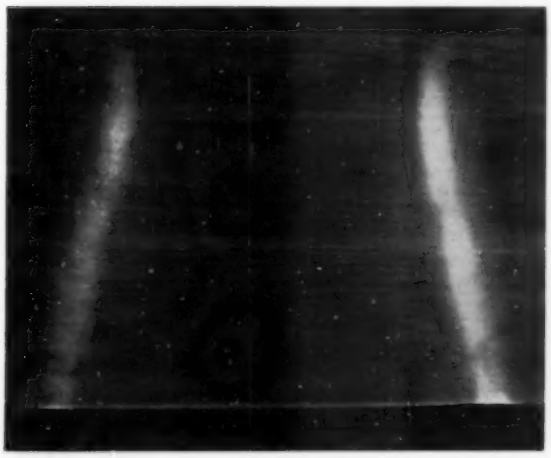


Figure 5. These two streaks of light are images of two continuous rows of luminaires reflected in the desk top. The fact that the top is both polished and dark produces a particularly severe reflected glare condition.

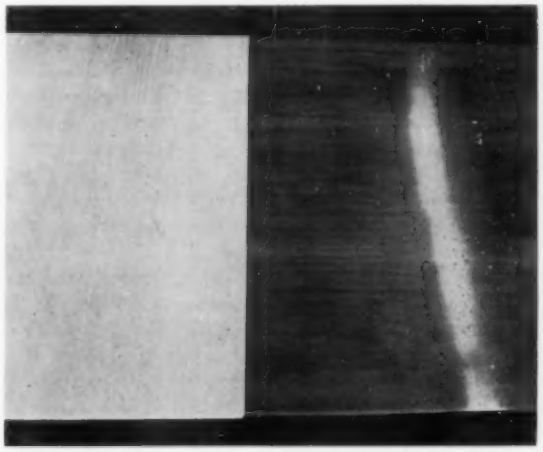


Figure 6. Reflected glare disappears when a piece of light diffuse linoleum is placed over the dark polished desk top.

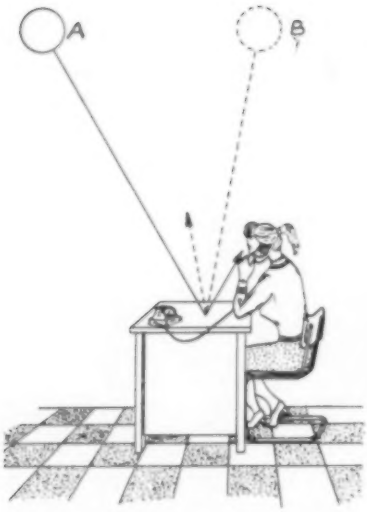


Figure 7. A lighting unit positioned at "A" is an inherent source of reflected glare in the desk top, whereas at "B" there is little likelihood of its causing this complaint. When the flexibility of layout permits, full advantage should be taken of such opportunity. In most instances, freedom from reflected glare must be accomplished by proper finishes on desks and other work surfaces and by proper luminaire brightness.

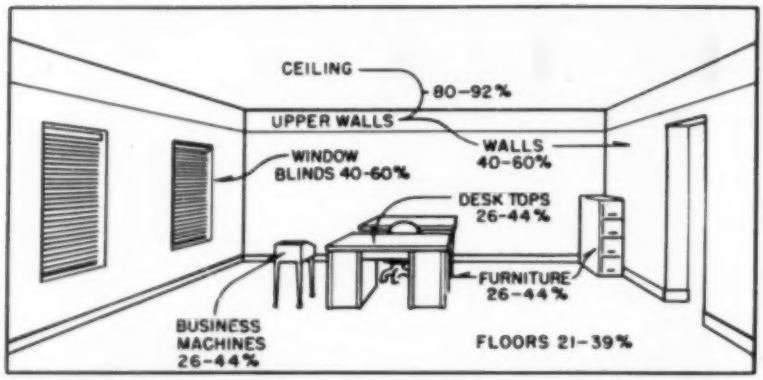


Figure 8. Reflectances recommended for room and furniture surfaces in offices.

TABLE III.—Recommended Surface Reflectances for Offices.

Surface	REFLECTANCE	
	"Center-point" Value and Tolerances	Equivalent Range
Ceiling Finishes*	.80 + 15%	80 — 92%
Walls	.50 ± 20%	40 — 60%
Furniture	.35 ± 25%**	26 — 44%
Office Machines and Equipment	.35 ± 25%**	26 — 44%
Floors	.30 ± 30%	21 — 39%

*Recommended reflectances are for finish only. Overall average reflectance of acoustic materials may be somewhat lower.
**American Standard Office Reflectances X2.1.3, 1954, UDC 535.312:651.2

eyes (Fig. 7). Existing installations may be easily and quickly checked for such reflections by moving a mirror about the seeing area. The absence of any source image will ensure the virtual elimination of reflected glare. The relative orientation of the task, work area, and luminaires or fenestration can often be coordinated in the layout stage if it is remembered that the angle of reflection equals the angle of incidence. Shiny, curved surfaces may, however, reflect annoying highlights regardless of orientation; they should either be eliminated or recommendation (4) below should be followed.

(4) When it is not possible or practical to observe any of the three recommendations given above, special precautions as to fenestration and luminaire brightness in the reflected glare zone should be observed. Luminaires and fenestration having *maximum* brightnesses (brightest square inch) in the order of 350 footlamberts (0.75 c/in^2) — and less — have generally proven to be satisfactory.

(5) Light sources should be so located that the illumination on the task comes from several different directions. Thus, if some luminaires or luminous areas are of necessity located at positions where they will cause reflected glare, other luminaires or portions of large area sources at different locations will provide favorable illumination that reduces the veiling effect produced by the offending light sources or luminous areas.

3.3.4 — *Illumination Uniformity* — Office lighting systems should be designed to provide satisfactory uniformity of illumination to permit flexible arrangement of office operations and equipment and to help assure more uniform brightnesses throughout the office area. Uniformity of illumination is considered satisfactory if the minimum value (often between luminaires) is two-thirds or more of the maximum value (often under the luminaires). If the minimum value is half or less of the maximum, perceptible differences in illumination exist.

To achieve satisfactory uniformity, it is essential that the lighting equipment be spaced in keeping with its light distribution characteristics and the physical characteristics of the room. Most manufacturers publish maximum spacing to mounting (or ceiling) height ratios* which should not be exceeded for their luminaires, and data are also available for predicting the daylight distribution from various types of fenestration. In most instances, the distance between luminaires and the wall should not exceed one half the distance between luminaires, and where desks are along the wall the distance between luminaires and walls should preferably be 2½ feet and in no case should exceed one-third the spacing between luminaires. The ends of continuous rows of fluorescent luminaires should preferably be within 6 inches to 1 foot of the wall and in no case more than 2 feet from the wall.

3.3.5 — *Shadows* — **(a)** Shadows cast *on the visual task* reduce the brightness of the task and hence impair effective seeing. When sharply defined at or near the task, shadows are annoying.

(b) Shadows will be softened if the light comes from many directions.

*May be determined for direct and semi-direct luminaires by "Classification of Luminaires by Distribution," Report of I.E.S. Committee on Illumination Performance Recommendations, ILLUMINATING ENGINEERING, November 1954.

High reflectance matte finishes on room surfaces become effective secondary light sources and materially reduce shadows by reflecting a significant amount of diffused light into shadowed areas.

4. Influence of Environmental Factors

4.1 — *General*

The eyes function most comfortably and efficiently when brightness ratios within the entire field of view are not excessive. A comfortable brightness balance in the room may be achieved by selecting luminaires in accordance with the recommendations outlined in Section 3.3.2 and employing matte finishes having the reflectances recommended in Table III and Fig. 8. By observing these recommendations, brightness ratios (see Table IV) will generally be within the limit established as being desirable and practical.

4.2 — *Room Finishes*

(a) The room surfaces (ceilings, walls, and floors) are important factors in determining the brightness ratios between the lighting equipment and its surroundings. The use of matte finishes having the recommended reflectances helps prevent excessive brightness ratios and specular reflections.

(b) The reflectances of room surfaces, as well as room proportions, have a considerable effect upon the utilization of light. Ceilings, walls, and floors act as secondary light sources of large area and, if finished with the recommended reflectances, will increase light utilization and reduce shadows.

(c) Although wall reflectances should generally fall within the range of recommended reflectances, under certain conditions higher or lower reflectances may be satisfactory or even desirable. The ceiling finish may, for example, be carried down the walls to the level of luminaires having a high upward component; utilization may be increased as much as 10 per cent by doing this. Conversely, a darker dado is sometimes employed on lower walls to minimize maintenance. Dados should have a reflectance of at least 25 per cent, however; darker dados are undesirable from the standpoint of visual comfort since the lower wall occupies an important part of the visual field. Small sections of walls may have re-

TABLE IV.—Recommended Brightness Ratios.

To achieve a comfortable brightness balance in the office, it is desirable and practical to limit brightness ratios between areas of appreciable size from normal viewpoints as follows:

1 to 1/3	Between task and adjacent surroundings
1 to 1/10	Between task and more remote darker surfaces
1 to 10	Between task and more remote lighter surfaces
20 to 1	Between luminaires (or fenestration) and surfaces adjacent to them
40 to 1	Anywhere within the normal field of view

These ratios are recommended as maximums; reductions are generally beneficial.

Figure 9. Dark desk tops such as this have reflectances of only four to seven per cent. The resulting excessive brightness ratios between the work and the desk top (frequently greater than 1 to 1/10) create an uncomfortable seeing condition.

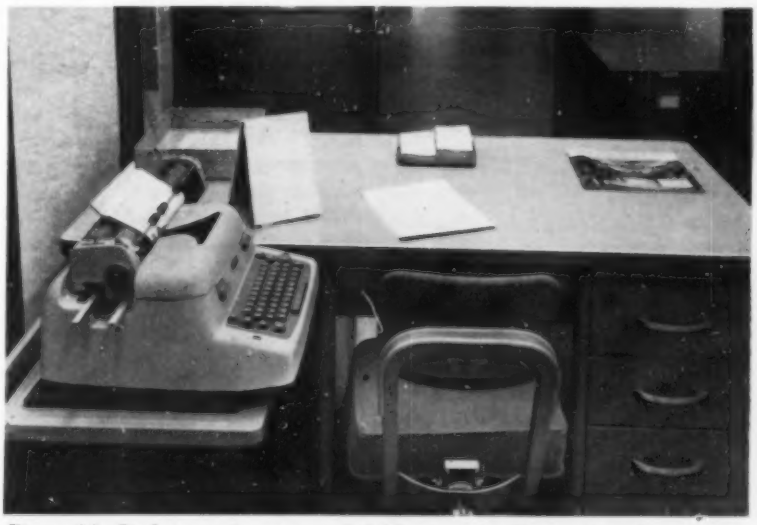


Figure 10. Desk tops of recommended 35 per cent reflectance result in brightness ratios between the work and these surfaces on the order of two to one. Under conditions of extreme dirt accumulation on such tops, the ratio will seldom exceed three to one. It is important that light finishes be employed on office business machines as shown here.

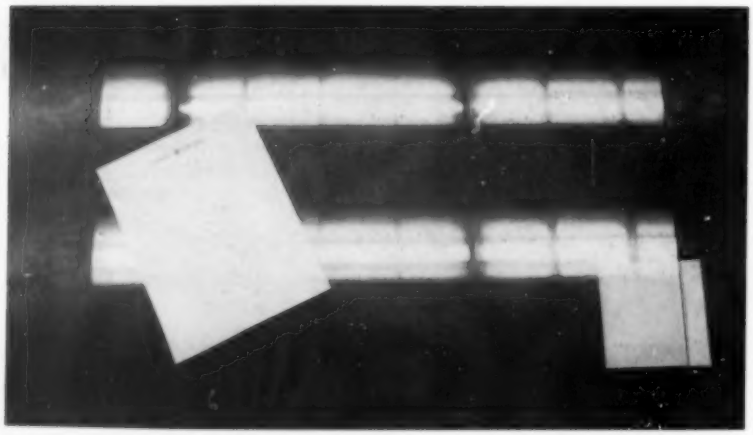


Figure 11. Images of luminaires become pronounced on glass-topped desks. The brightness of these images will frequently exceed that of the work and may actually conceal reference material under the glass.

flectances higher or lower than the extremes permitted by the range given in Table III. If these areas are thought of as accents and restricted to about 10 per cent of the total wall area in the room, little harm will be done to the efficiency of the lighting system or to the significant environmental brightness ratios, while the environment can be made to look considerably more pleasant and interesting. Entire walls having reflectances higher or lower than the extremes permitted by the range given in Table III should be used only with discretion and by an experienced designer who recognizes the precautions that must be taken.

(d) When window shielding media act as walls they should have at least as high a reflectance as that recommended for the walls.

4.3 — *Office Equipment Finishes*

4.3.1 — *Furniture* — **(a)** No surface in the office is more important visually than the desk top. For a person working at a desk, the top occupies most of the visual field. The task is usually of high reflectance, and desk tops having the reflectance recommended in Table III are necessary to prevent the brightness ratio between the task and its surround from exceeding one to one-third ratio that is considered desirable and practical (Figs. 9, 10). Matte finishes are, of course, essential to minimize reflected glare (Fig. 11).

(b) All office furniture should have a light finish that harmonizes with the environment and promotes seeing comfort by minimizing brightness ratios between the various surfaces within the visual field. It is particularly important that the vertical surfaces of dessks and file cabinets have finishes of the recommended reflectance, for they occupy a significant portion of the visual field. Since these surfaces receive less illumination than adjacent horizontal surfaces, light finishes are necessary to make them even moderately bright.

4.3.2 — *Machines* — Business machines rank with desk tops in visual importance. In use they occupy a central and dominating part of the visual field even when operated by the touch system. Finishes having the recommended reflectances are essential for seeing comfort; shiny surfaces and dial covers should be completely eliminated, for even a small amount of specular trim can be distracting and annoying even though it may not be viewed directly.

4.4 — *Color*

(a) The hue or number of hues selected for an office area depends on the size of the area, the type of work performed by the occupant or occupants, the number of consecutive hours the occupant spends in the office, the orientation of the office, and the type, condition and amount of furniture needed for the operation of the office. Color preferences of the occupant (or occupants) may be a helpful factor.

(b) If the office is small it can be made to appear larger and less crowded if walls, woodwork, and furniture placed against these walls are in the same hue or are of the same reflectance. A contrasting color or a lighter or darker value of the same color may be used at some point or points in the room. This note may be in the draperies, the upholstery for chairs or sofas and any added wall decoration, such as pictures. Small touches of accent color will give vitality and dramatic interest to a room.

(c) If the office area is not well proportioned, it is possible through the intelligent use of color to make it seem less awkward. The use of light values for backgrounds makes the office appear larger. One or two (adjacent) walls in a color different from that of the others is also helpful. The ceiling should be matte white. The appearance of high-ceiling rooms is improved and the lighting efficiency is increased if the ceiling paint is carried down along the top of the walls.

(d) Because it is human nature to desire at least occasional change, architects and lighting designers will be wise to specify the reflectances for all surfaces in an interior and plan the lighting so the colors can be changed without destroying the planned effect. If this information is included in the specifications and marked on all blueprints anyone can not only do the original color for the room but any replacement color plan as long as the lighting system is in use. The person planning the colors for the interior should have a knowledge of color harmonies and an understanding of the importance of maintaining the recommended reflectances. Then the lighting system, the color for the environment desired, and the architecture will have unity and flexibility.

(e) In large offices the similarity of desks and equipment arranged in a repetitive pattern tends to give a sense of coldness, stiffness and monotony. Change of pace and points of interest can be effected through the use of varied patterns in wall space. Gradations, variations and accents of color, areas of figured wall paper, items and objects of interest break up monotonous continuity and provide focal points of attractiveness. This must be done carefully to preserve a sense of harmonious unity to the whole interior.

5. Lighting Systems for Office Areas

5.1 — *Daylighting Systems*

5.1.1 — *General* — **(a)** Fenestration areas can serve at least three useful purposes in offices. They can provide for the admission, control and distribution of daylight for seeing, provide a distant focus for the eye and thus relax important eye muscles, and eliminate the dissatisfaction many people experience in completely closed-in structures.

5.1.2 — *Important Daylight Considerations for Office Areas*

(a) Detailed discussion of daylighting principles will be found in the I.E.S. "Recommended Practice of Daylighting." The following are interpretations of the pertinent passages of this practice.

(b) *Building orientation and site conditions* — The fenestration system should be developed to suit the orientation, variations in topography, and landscaping related to each exterior wall (Fig. 12).

(c) Brightness control devices adapted to the control problems encountered should be provided for all fenestration areas (Fig. 13).

1. *North elevations* — No direct sunlight will strike near-vertical surfaces within about 20 degrees of true north during the usual work day. Therefore, the control media should be designed for the sky, cloud and near-by object brightnesses that may be experienced in the range of 500-5000 footlamberts.

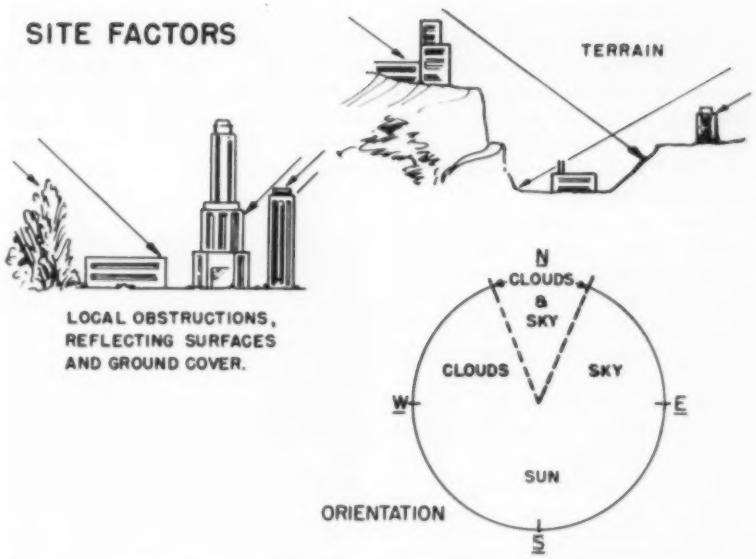


Figure 12. Site factors that influence the amount of daylighting that may be expected in offices include local obstructions, reflecting surfaces, ground cover, terrain and orientation.

2. *Sunny elevations* — With fenestration areas frequently receiving 9000 or more footcandles, special attention must be given to glare control and daylight distribution on these elevations.

5.1.3 — *Effective Utilization of Daylight* — **(a)** Daylight illumination distribution is improved when light is introduced through more than one room surface.

(b) Care must be taken to provide brightness control for the narrow continuous windows often associated with fixed fenestration systems.

(c) To provide adequate daylighting of interior corridors or other areas located more than three times ceiling height from an exterior wall, toplighting may be required (Fig. 14).

(d) Suitable fenestration materials for offices include single and double-glazed plate and window glass, both clear and heat-absorbing, combinations of clear and obscure glass, plastics, and glass blocks.

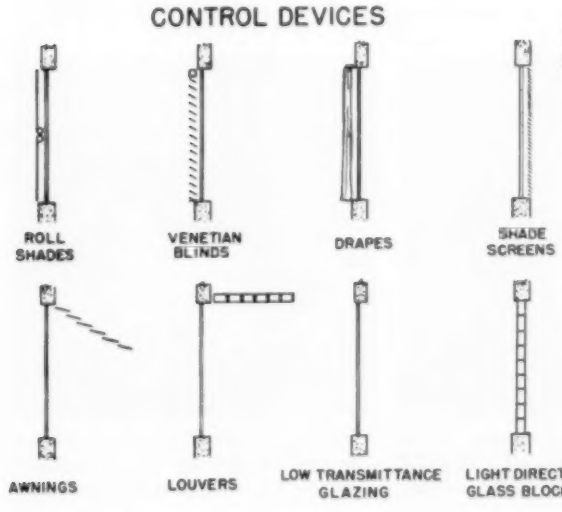
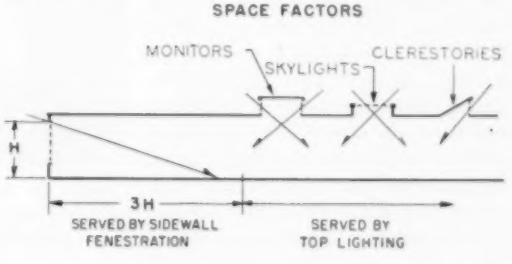


Figure 13 (left). Uncomfortable high brightnesses from daylighting may be prevented by any of several types of fenestration control devices.

Figure 14 (below). Space factors for daylighting.



(e) Except in the case of glazing media with integral controls that control brightness within comfortable limits, the fenestration plans should include provision for the use of supplementary roller shades, draw drapes, venetian blinds, louvers shade screens or awnings (Fig. 13).

(f) With clear glazing, the upper portion of the window is most effective in lighting the deepest portions of a room. Thus the treatment of the window area nearest the ceiling is of great importance in producing useful levels in the rear of a room.

(g) When light-directing glass or glass block panels are used, they should begin approximately six feet above floor level. They are particularly effective in lower ceiling rooms, since the lower band of blocks near the six-foot sill delivers most of the light to the deeper portions of the room.

5.2 — *Electric Lighting Systems*

5.2.1 — *Types of Electric Lighting Systems*

5.2.1.1 — *General* — All interior lighting systems are included in one of the following five classifications. These comments refer specifically to applications in office areas.

5.2.1.2 — *Indirect* — **(a)** With this system, 90 to 100 per cent of the light from the luminaires is first directed to the ceiling and upper sidewalls from which it is reflected to all parts of the room (Fig. 15). The recommended high reflectance, matte room surface finishes are obviously essential to obtain reasonable utilization of the light, and these surfaces should be kept in good condition to maintain their high reflectances. Frequent cleaning of luminaires is important.

(b) The highly diffuse character of the light from indirect systems results in minimum shadows. Both direct and reflected glare are also minimized if the installations are well-planned. To this end it is desirable that the luminaire brightness approximate that of the ceiling, and the luminaire should be suspended a sufficient distance below the ceiling to prevent excessive ceiling brightness above the luminaires and to obtain as nearly as possible a uniform brightness distribution over the entire ceiling.

(c) Although indirect lighting systems providing illumination levels within the ranges recommended in Table I are usually comfortable, indirect lighting may be unsatisfactory at higher levels unless the installation is so designed that the ceiling brightness conforms with the limitations suggested in paragraph 3.3.2 (e).

5.2.1.3 — *Semi-Indirect* — **(a)** These systems emit 60 to 90 per cent of the luminaire output upward toward the ceiling and upper sidewalls while the rest is directed downward (Fig. 16). Since this type of lighting also utilizes the ceiling as the main source of light,

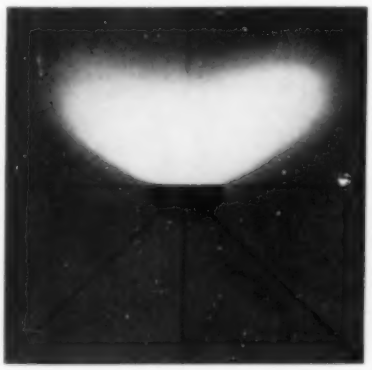


Figure 15. Indirect lighting; 90-100 per cent of luminaire output directed upward, 10-0 per cent downward.

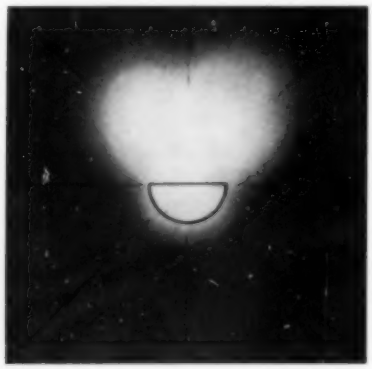
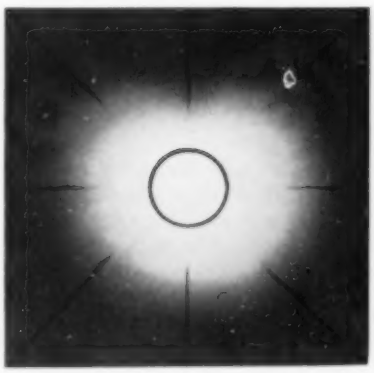


Figure 16. Semi-indirect lighting; 60-90 per cent of luminaire output directed upward, 40-10 per cent downward.



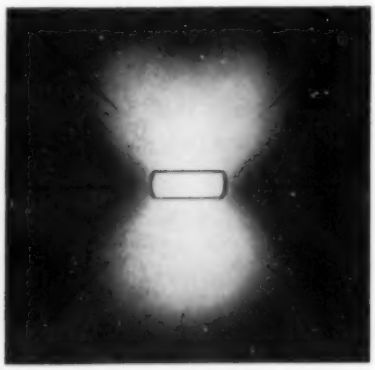


Figure 17. General diffuse lighting; 40-60 per cent of luminaire output directed upward or downward; (left) diffusing enclosure, (right) direct-indirect lighting.

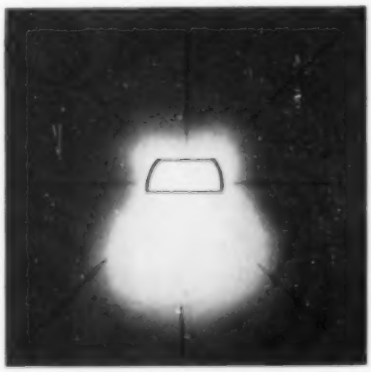


Figure 18. Semi-direct lighting; 60-90 per cent of luminaire output directed downward, 40-10 per cent upward.

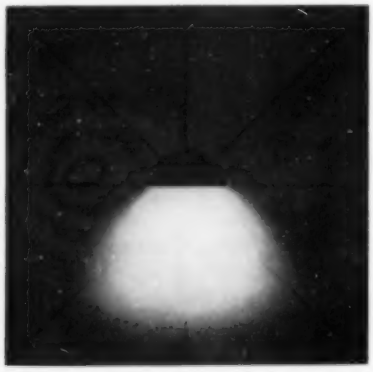


Figure 19. Direct lighting; 90-100 per cent of luminaire output directed downward, 10-0 per cent upward.

the same considerations as for indirect lighting should be observed with regard to room finishes and good maintenance.

(b) In general, semi-indirect units are characterized by luminous surfaces which help achieve low brightness ratios between the ceiling and the luminaire, but as the downward component increases, the factors of direct and reflected glare may require attention.

(c) Because of the downward component, utilization with semi-indirect lighting is slightly higher than with indirect lighting. It is therefore, possible to obtain somewhat higher illumination levels with fewer luminaires and without excessive ceiling brightness.

5.2.1.4 —*General-Diffuse or Direct-Indirect* — **(a)** This classification refers to systems where the downward and upward components are about equal (each 40-60 per cent of total luminaire output) and the resulting illumination is predominantly from the downward component (Fig. 17). General diffuse luminaires distribute light about equally in all directions; direct-indirect luminaires emit very little light at angles near the horizontal. The latter are, therefore, generally more suitable since they are lower in brightness in the direct glare zone.

(b) With these systems, utilization is very good, but shadows may be more noticeable than with indirect and semi-indirect systems, and some difficulty may be experienced with direct glare from the general-diffuse types or some of the inadequate shielded direct-indirect luminaires. Since maximum brightnesses in the reflected glare zone will generally be in the 1000-2400 footlambert range, care must be taken to employ high reflectance, matte finishes on all furniture and machine surfaces. Design for proper orientation as outlined in Section 3.3.3 (d) (3) should also be observed.

5.2.1.5 — *Semi-Direct* — **(a)** In this classification 60 to 90 per cent of the luminaire output is directed downward toward the work surface (Fig. 18). The smaller upward component illuminates the ceiling thereby increasing diffusion and reducing the brightness ratio between the luminaire and ceiling.

(b) As the downward component increases, more attention must be directed to minimizing shadows by designing the installations so that the light at any work point comes from many directions. The use of large area sources also helps soften shadows. High reflectance, matte finishes on furniture and business machine surfaces are essential to minimize reflected glare. Careful orientation as outlined in Section 3.3.3 (d) (3) should also be observed insofar as possible.

(c) When general-diffuse or direct-indirect luminaires are mounted close to the ceiling, the distribution characteristics of the luminaires change to semi-direct. It should be recognized that the luminaire brightness will be increased when it is mounted close to the ceiling, and the brightness of the ceiling above the luminaires will often materially exceed the brightness of the luminaire. Determination of the suitability of luminaires to be so mounted should be based upon distribution curves made in accordance with I.E.S. Testing Guides wherein the luminaire is photometered with a simulated ceiling pan.

5.2.1.6 — *Direct* — **(a)** Units in this classification are defined as those which direct practically all (90 to 100 per cent) of the light downward (Fig. 19). The directional characteristics of this type of lighting may produce disturbing shadows unless the units are of large area or are closely spaced. Direct glare and excessive brightness ratios may be prevented by reducing the brightness exposed to normal view (Section 3.3.2) and by illuminating the ceiling through the use of high reflectance room and furniture surfaces which will redirect a significant amount of light to the ceiling. The precautions outlined above for the prevention of reflected glare from semi-direct luminaires must be followed to an even greater degree with direct luminaires.

(b) Ceiling *Area Lighting* extending essentially from wall to wall is also a form of direct lighting where light from sources in a large cavity of high reflectance is directed downward through cellular louvers or translucent or refracting glass or plastic. The illumination characteristics of this form of lighting are similar to those obtained with indirect lighting systems. Although this form of lighting is frequently used to obtain illumination levels materially exceeding those recommended in Table I, care must be taken in large office applications to limit the brightness of the shielding and transmitting medium to values below the 250-footlambert value suggested in Section 3.3.2 (e). Baffles offer another means of improving comfort in large offices, and they may be of acoustic material to simultaneously provide sound conditioning;. Reflected glare may also be a problem with area lighting systems employing cellular louvers as the shielding medium since specular surfaces at the working plane will pick up reflections of light sources that are visible when looking up into the cells.

5.2.1.7 — *Summary* — **(a)** No one system can be recommended to the exclusion of all others, for each has characteristics that may or may not match the requirements of a given application. The performance of each should be evaluated first as to whether it will efficiently provide lighting to meet the basic needs of a comfortable environment in the office; secondly, the appearance of the equipment in the completed installation should be in keeping with the architectural and decorative design of the office.

(b) Indirect lighting and direct ceiling area lighting systems are characterized by relatively low source brightnesses throughout both the direct and reflected glare zones, good diffusion and freedom from shadows, and, in the case of indirect lighting, low to moderate utilization. On the other hand, utilization is good with direct lighting, but the quality of illumination required for office tasks may be obtained only if precautions are taken to closely space the luminaires or use large area low brightness equipment. Intermediate systems combine the characteristics of indirect and direct lighting in varying degrees depending upon the predominant component.

6. Lighting and Seeing in Specific Areas

6.1 — *Private Offices*

(a) Private offices are usually of moderate or small size. Either direct or indirect lighting can be applied satisfactorily since much of the lighting equipment on the ceiling itself is generally not within the visual field. Smaller rooms, it must be pointed out, accentuate the inefficient utilization of indirect lighting. The arrangement and orientation of furniture in the private

Figure 20. An "L" shaped layout with direct-indirect luminaires located over the actual work area results in more illumination on the task than would be obtained with a conventional, symmetrical layout. This functional arrangement also minimizes direct and reflected glare since the luminaires are out of the viewing field and reflections will be directed away from the eye.

Figure 21. This installation of semi-indirect luminaires is arranged in a "U-shaped" pattern over and around the work area to obtain maximum illumination on the task with minimum direct and reflected glare.

Figure 22 (right). The rectangular arrangement of troffers in this executive office is wired so that each side of the rectangle can be switched separately to obtain any functional lighting pattern desired. The diffusing plastic ceiling enclosed by the rectangle is trans-lighted to a low brightness (about 1/5 that of the troffer diffusing glass) to improve seeing comfort by eliminating the large expanse of dark ceiling which would otherwise be present.

office is fixed and permits the placement of direct lighting equipment to minimize both direct and reflected glare. A lighting system may literally be designed for and around the office desk and furniture as illustrated in Figs. 20-22.

(b) Other factors of comfortable lighting must not be violated. Not only is it necessary to provide satisfactory illumination for the occupant at the point of work, but sufficient brightness on walls, floors and other areas is necessary to avoid high brightness ratios with the work. Some consideration should be given to others occasionally entering the office. The use of dark paneled walls, desks and floor coverings is not conducive to comfortable seeing and higher reflectance materials with equal decorative character are now available.

(c) The illumination required in private offices varies from that neces-

Figure 23. The plastic louverall ceiling in this office provides an average maintained illumination level of 75 footcandles, and additional daylighting may be provided by opening the draw draperies shown.

Figure 24. Two 6 x 8-foot modular elements employing 8-foot slimline lamps mounted 8 inches above the centerline of each of the low-brightness prismatic glass lenses provide an average illumination level of 85 footcandles in this office.

Figure 25. This installation of large area (4 feet square) recessed luminaires with diffusing plastic shielding exemplifies the coordination of light and architecture in a group of modern executive offices.

Figure 26. In this executive office, a 2-lamp fluorescent cove around the periphery of the room provides over 30 footcandles on the desk and table. Functionally located, recessed incandescent luminaires boost the illumination on the desk and table to an average of 76 footcandles.

sary for casual seeing during interviews to high values for prolonged study of reports, financial statements, plans and specifications. Where possible, the lighting system should be flexible to provide the order of illumination the varying tasks indicate. The higher values should be employed only when adequate provision is made for reduced brightness ratios between the lighting system and the environment, between the work and the environment, and among the environmental areas themselves.

6.2 — *General Offices*

(a) Most general offices are moderate to large sized areas in which there is no protection by reason of size limitations from lighting units being located directly in the field of view. In these areas, it is particularly important to avoid units of the general diffuse type. At the same time, it is in the general office that seeing is most frequently difficult and most nearly continuous and, for this reason, quality and seeing comfort should never be compromised. The minimum quantity of light in use should be in keeping with recommendations in Table I. Details of visual tasks should be of reasonable size and have good contrast. Finishes, color and other environmental factors should be selected to assure full benefit from the lighting and to supplement all the advantages that can be realized in the tasks themselves.

(b) Since many office operations require more than one orientation of personnel, lighting and seeing should be comfortable for all directions of view. Changes in routine or personnel frequently require rearrangement of desk locations and partitions. General lighting installations originally designed to be comfortable from all directions need not be modified with changes in office procedure or organization. Where the existing system has a marked advantage of direct view comfort for one orientation of view, personnel should be oriented to take advantage of this situation.

Figure 27. Continuous rows of 2-lamp semi-indirect fluorescent luminaires provide 35 footcandles in this private office. The rows are arranged for the most favorable viewing of the luminaires by a person seated at the desk, and the luminaire brightness is approximately that of the ceiling.

Figure 28. In this semi-private office parabolic aluminum troffers were combined with luminous panels to produce an average illumination level of 104 footcandles after three months in service. Of this level, 90 footcandles are provided by the troffers.

Figure 29. A high degree of diffusion with minimum direct and reflected glare is obtained with this semi-indirect lighting installation.

Figure 30. Direct-indirect lighting from suspended fluorescent luminaires with louver bottoms and either opaque or luminous sides is one of the currently popular methods of lighting, because it combines good diffusion and adequate shielding from direct glare with high utilization and reduced maintenance. When equipped with luminous sides, the luminaires should be oriented for lengthwise viewing for greatest seeing comfort. Opaque-sided luminaires such as shown here may usually be viewed comfortably from either direction, but crosswise viewing is often preferred.

Figure 31. Continuous rows of two-lamp, louvered, semi-direct luminaires suspended 8 inches from the ceiling, maintained a level of 92 footcandles in this office. Additional illumination is provided by clear glass fenestration with venetian blind shielding.

Figure 32. High reflectance finishes throughout this office and a luminous ceiling providing an average level of 80 footcandles after 6 months' service result in a pleasant, comfortable environment with excellent seeing conditions.

Figure 33. Direct-indirect luminaires with metal sides, 45° x 45° louver bottoms and two 40-watt T-17 low brightness lamps were suspended approximately 16 inches below the ceiling in this installation to maintain a minimum average level of 50 footcandles. The luminaires were installed in double row runs, separated somewhat for maintenance, to improve the appearance of the installation by minimizing the apparent number of rows. These luminaires are supplemented by surface mounted units mounted on the bottoms of beams and ducts.

Figure 34. Acoustic baffles are frequently combined with luminous ceilings to to provide sound conditioning, break the monotony of overall area lighting, and reduce the total amount of luminous area in direct view.

Figure 35. Troffers should usually be oriented for crosswise viewing as shown here. In this office, light desk tops and floors redirect some of the light back to the ceiling to minimize the brightness difference between the troffer and the ceiling.

Figure 36. This banking office is characterized by an unusual and functional design of both the daylighting and electric lighting systems. A wall of light-directing glass block provides good general lighting, and recessed incandescent units and fluorescent troffers provide additional illumination on the work areas.

Figure 37. One of the recent trends in office lighting is the use of large area, modular lighting elements. These 2 x 4-foot recessed fluorescent luminaires with diffusing plastic bottoms are so installed that they can be easily removed at any time and reinstalled in any of the 2 x 4-foot spaces now occupied by acoustic ceiling boards. Additional luminaires could also be similarly installed at any time.

Figure 38. Adequate illumination and comfortable brightness relationships are maintained in this office by daylighting and electric lighting systems that use prismatic glass to control the lighting distribution.

Figure 39. Surface-mounted, large area modular fluorescent lighting units with plastic diffusers are finding increased favor in offices, although their use is by no means limited to such application.

(c) Care should be taken to provide the recommended quantity of illumination on the actual work surfaces. Most are horizontal, but some are vertical or sloping. Extra precautions should also be taken to insure proper distribution of light along the sides and ends of offices. Desks are frequently placed along walls where the amount of light is inherently less if provisions have not been made to offset this reduction. This is generally accomplished by spacing luminaires more closely along the walls of an office area as recommended in Section 3.3.4. High reflectance finishes on walls increase the amount of light on desks in these positions.

6.3 — *Drafting Rooms*

6.3.1 — *General* — Drafting makes very serious demands upon the eyes and requires a high level of high quality illumination. Drafting involves accurate discrimination of fine details, frequently over long periods of time. The contrast between the work detail and its background may be very poor, as, for example, when tracing a faint blueprint or worn pencil drawing. Specular drawing surfaces, polished T squares, plastic triangles, and scales are potential sources of reflected glare. Shadows along the drawing edge of the T square or a triangle may materially reduce visibility; or strong, multiple shadows from the drawing instruments or the draftsman's hands may prove annoying.

6.3.2 — *Reflections* — On nearly horizontal boards, any ceiling or luminaire brightness may be reflected by the work to the eyes of the draftsman. Such reflections may sometimes be eliminated by proper positioning of the source or control of the direction of light flux with respect to the specular surfaces so that reflections will be directed away from the eye. It is usually more practical to minimize the effect of these reflections by controlling the brightness of the luminous area that is reflected to a low and fairly uniform value. This may be accomplished by employing lighting systems such as luminous indirect, semi-indirect (Fig. 40) or luminous ceilings. With the board in a nearly vertical position, specular reflections cause little if any trouble since they will be directed toward the floor. Furthermore, the nearly vertical board may be high enough to shield the eyes of the draftsman from luminaire brightness otherwise in the field of view.

Figure 40. The 50-footcandle semi-indirect fluorescent lighting system in this drafting room minimizes direct glare and reflected glare and T-square and triangle shadows. There is no limitation on placement of tables because of direction of light, but this type luminaire is viewed most comfortably from a lengthwise direction.

6.3.3 — *Shadows* — Where boards are near horizontal, edges of T squares or triangles parallel to line sources having strong direct components may cast sharp line shadows. Use of indirect, semi-indirect, or other forms of overall ceiling lighting will minimize such shadows. Where this type of lighting is not applicable or feasible, the frequency of occurrence of such shadows may be minimized by orienting either the luminaires or the drafting tables to create an angle of 15 to 20 degrees

Figure 41. In drafting rooms where boards are near horizontal, the working edges of triangles and straight edges parallel to line sources having strong direct components may cast dark line shadows which obscure the work and confuse the draftsmen. To minimize the frequency of occurrence of such shadows, the luminaire rows are sometimes oriented at an angle of 45 degrees as shown in this 150-footcandle installation.

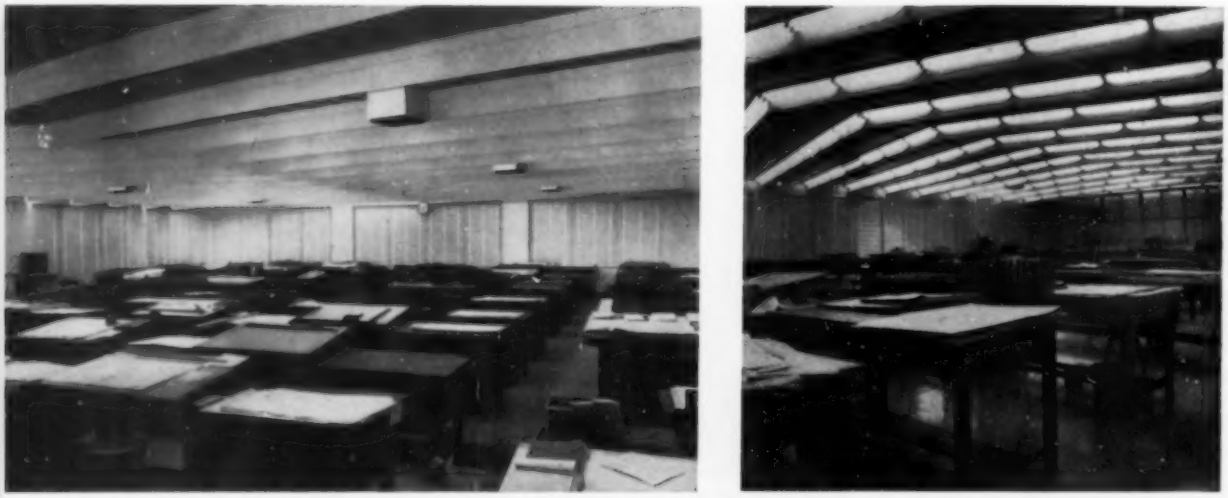


Figure 42. In this engineering-drafting office where all draftsmen face the same direction (left), 2-lamp bare lamp channels were installed in front of steel shielding baffles to obtain 100 footcandles of comfortable illumination. The baffles form diagonal rows on 5-foot centers meeting at the center of the room. They have a white baked-enamel finish on the lamp side and a buff finish on the viewing side to obtain the uniform brightness conditions shown (ceiling, 70 footlamberts; baffles, 190 footlamberts; sidewalls, 180 footlamberts; front wall, 280 footlamberts). The baffles are run at an angle of 17 degrees from a perpendicular line to the sidewalls to obtain best shielding and prevent possible line shadows of sources running parallel to the working edges of triangles and straight edges. (Right) same installation as at left, when viewed from the opposite direction.

between the long axes of the luminaires and any of the major straight-edge positions (Figs. 41, 42). Use of vertical drafting boards also virtually eliminates shadows (Fig. 43).

6.3.4 — *Transillumination* — A drafting table with a diffusing surface panel illuminated from behind to a brightness on the order of 300 footlamberts is recommended for tracing in rooms with 50 footcandles of general illumination (Fig. 44). This method is much more effective than providing illumination by overhead lighting. It is desirable to keep the temperature of the tracing table as low as possible; therefore, light sources such as fluorescent having a high light output per watt should be selected. The desirable brightness of the glass depends on the nature of the work and the level of illumination from above. To avoid direct glare, the draftsman should use opaque paper to cover the portion of the glass which is not concealed by the drawing.

Figure 43. Parabolic, single-lamp aluminum troffers offer an excellent means of lighting this drafting room where near-vertical drafting boards are employed. Additional luminaires are installed adjacent to the wall to offset the reduction in illumination which normally occurs near a wall.

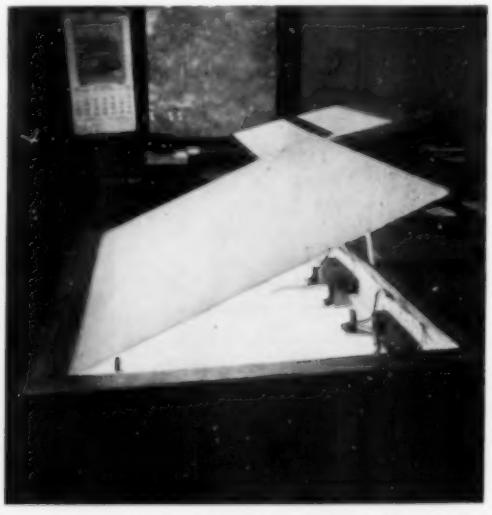


Figure 44. This tracing table is lighted from below by means of 20-watt T-12 fluorescent lamps on 6-inch centers.

6.4 — *Files*

(a) Files present the particular problem of work surfaces that are vertical, inclined and horizontal and frequently stacked one against the other. In order to provide the recommended values of illumination *on work surfaces other than horizontal,* it is generally true that considerably higher values will need to be developed on horizontal positions. In *active filing* areas, the work is likely to be of protracted nature and the visual task is of more than average severity. Where the room is primarily devoted to files, consideration should be given to special luminaires designed and located to provide a uniform, high illumination level on vertical surfaces. Highest quality illumination with values higher than those shown in Table I should often be provided. For the lighting of *dead files,* the same general principles of design should be followed but some reduction in the level and quality of illumination is permissible. For files used intermittently, recommended values are sufficient.

(b) Filing may involve correspondence which is frequently a carbon copy on low grade paper or may be cards and data sheets of various kinds with closely spaced figures and rules. While the majority of material in files is white, colored stock is often used for correspondence and certain card files. The type of stock being used should be investigated to make sure that no more than the necessary identifying tint is employed and that deep, saturated colors are avoided. There are certain modern filing systems which have "visible" indexes. These are frequently covered by transparent material which is shiny and picks up bright reflections. If the use of these materials is to be continued, the lighting units should be so installed that reflected glare will be directed away from the worker's eyes. Where conditions do not permit these improvements, the use of large area low brightness lighting units such as shown in Fig. 46 is essential.

(c) Cabinet finishes of recommended reflectance will provide comfortable brightness ratios within the environmental areas of file rooms and will improve the seeing conditions at the point of work. Lighter finishes will reflect more light down between filed items which frequently are read without removal from the files.

6.5 — *Mail Rooms*

Much of the seeing in mail rooms is but moderately difficult, so that the illumination recommended for ordinary seeing tasks should prove adequate. Rapid sorting and routing of incoming mail involves rather difficult seeing, however, and if the activity is carried on for a considerable period of time, the illumination should be increased commensurately. Pleasant, comfortable conditions should be provided through proper control of environmental color and finishes.

6.6 — *Conference and Board Rooms*

Effective coordination of good seeing conditions with the architectural and decorative designs of these rooms will result in comfortable and attractive areas. As in private offices, the use of these rooms varies considerably, but critical and prolonged seeing is encountered at times in most of them. No less than 30 footcandles should be provided over the working area at and around the conference table, and the illumination should be diffused to eliminate shadows on the faces of persons seated around the table. Undesirable reflections should be avoided. Moderately high reflectance matte finishes are recommended. Special attention to lighting of vertical surfaces is important if charts, displays or illustrations are frequently studied. Supplementary lighting is recommended for this purpose. Flexibility in providing light suited to varying use can be provided through suitable switching or dimming.

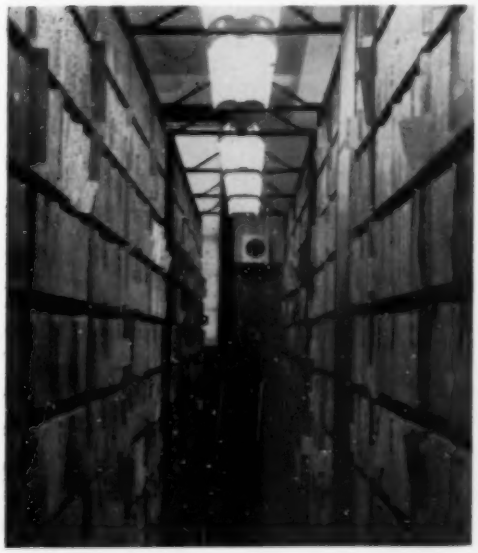


Figure 45. Two-lamp fluorescent luminaires with louver shielding provide excellent vertical illumination on the field material in these high, open-shelf type files.

Figure 46. A large area, low brightness modular unit over these files minimizes the reflected glare that could occur in the plastic-covered file tabs.

Figure 47 (left). In this small conference room, the wedge-shaped table permits conferees and chairman to see each other directly. Each line of the general lighting equipment above the rows of chairs is fully shielded from the view of seated persons; this lighting provides 100 to 150 footcandles across the conference table. The draperies back of the chairman's position may be drawn to expose a screen or a well-lighted presentation area.

Figure 48 (below). A combination incandescent system of cove lighting, recessed rectangular lens units, recessed baffle downlights, and recessed louvered units provide an effective means of lighting this Board Room.

Figure 49. Deep wooden louvers, 12 inches square, 9 inches deep, one inch thick, and tinted light green are used to conceal 96T12 slimline lamps on 24-inch centers, 20 inches above the louvers. Downlights are used in the window alcove; portable lamps for accent.

Figure 50. This corridor lighting installation consists of a continuous row of single-lamp fluorescent luminaires with wrap-around louvers that provide excellent endwise shielding, but do not obstruct the sideward light that illuminates the walls so uniformly. Satisfactory results could also be obtained with such equipment spaced intermittently down the corridor length.

Figure 51. Intermittently spaced two-lamp louvered troffers are employed to provide the excellent corridor lighting shown here. It should be noted that the luminaires are installed parallel to the length of the corridor; this orientation is usually preferable for all types of fluorescent luminaires installed in corridors.

Figure 52. This new and effective method of lighting corridors combines an acoustical ceiling with a louver system to provide good brightness of wall and ceiling. The acoustic ceiling has been extended only part way across the corridor with the remaining distance emitting light from a continuous row of fluorescent lamps concealed above the louver system spanning the remaining distance.

Figure 53. Large area fluorescent luminaires (4-feet square) installed end-to-end in the corridor and stairway area maintained a high level of illumination that is comparable to the illumination in adjacent office and conference area.

6.7 — *Reception Rooms*

(a) Lighting for casual seeing fulfills the requirements of the usual reception room. Glare should be avoided to make the room pleasant in general appearance and to provide comfortable seeing for those visitors who choose to read while waiting. The choice of higher reflectance values for room surfaces and furnishings will assist in making the room comfortable and seem more spacious.

(b) If a receptionist occupies the room, this person should be provided with lighting in keeping with the tasks assigned. Frequently, general office work is part of the assignment and the seeing requirements are more exacting than those for the casual occupant. Brightness ratios in the receptionist's visual field should be limited to low values and either a uniform amount of light throughout the room or with more light provided at the work area commensurate with the severity of the work assignments. The latter requires particular attention as to brightness patterns on walls, floors and desk tops.

(c) If a PBX board with signal light indicators is present, it is important that the general lighting not "wash out" the signal lights (particularly if they are located on a horizontal plane). Care should also be taken to prevent reflections of bright light sources in the signal light caps.

6.8 — *Corridors and Hallways*

The primary consideration in lighting corridors is safety, although appearance is of considerable importance. The spacing of lighting equipment from center to center should not exceed one and one-half times the mounting height and an average level of not less than ten footcandles should be maintained. It is recommended that the amount of light in hallways be no less than 20 per cent of that in adjacent areas, but hallway illumination levels that are at least one-third of the levels in adjacent offices have been found to be preferable from the standpoint of relieving brightness differences between hallways and offices. The illumination values specified for hallways are to be provided at floor level. Lamps should be shielded in the direction of view. Reflectances for ceilings, walls, and floors should equal or exceed those recommended for the offices. If dark finishes must be used from the maintenance standpoint, they should be limited to the dado.

6.9 — *Stairways, Escalators, and Elevators*

The need for good lighting at these points is paramount in the interest of safety. Installations should be so designed that failure of one lamp will not leave an area inadequately lighted. Floor, wall and overhead finishes should be of high reflectance to gain the maximum utilization of the light and to reduce shadows.

6.9.1 — *Stairways* — **(a)** Stairway lighting equipment should be so located and shielded that persons neither cast shadows on the stairs nor encounter glare at eye level. A unit should be located at least on every landing and more closely if necessary.

(b) Special treatment may be necessary to call attention to changes in elevation in corridors where one or two steps are necessary. This may be accomplished by placement of small, shielded lighting units recessed near the floor or by distinctive painting of the edges of the steps.

6.9.2 — *Elevators* — Good lighting of the threshold should be provided to call attention to any difference in level between the landing and the car. It is recommended that the car interior be of as light a finish as is consistent with reasonable ease of maintenance.

6.9.3 — *Escalators* — Good lighting should be provided on the tread, using shielded supplementary fixtures in the balustrade if necessary. Finishes should be of a light nonspecular type.

6.10 — *Personal Service*

(a) Sanitary maintenance of restrooms and washrooms is considerably improved by sufficient illumination throughout the areas. Not less than 10 footcandles or 20 per cent of the illumination in adjacent offices is recommended.

(b) When lounges are incorporated as part of washrooms, casual reading will require an illumination level in accordance with such tasks (see Table I). This may be provided by supplementary lighting if desired. Mirror lighting and similar residential treatments improve the appearance and usefulness of these personal service rooms.

Figure 54. The general lighting in this washroom is provided by surface mounted fluorescent luminaires equipped with cross louvers. Additional lighting is provided at the mirrors and wash basins by a continuous fluorescent wall unit mounted over the mirrors.

Figure 55. Supplementary lighting is often required for visual tasks of fine detail or poor contrast that must be viewed for prolonged periods — particularly if they are on near vertical surfaces.

7. Other Considerations

7.1 — *General*

There are certain specific considerations of importance in addition to the general factors of office seeing and lighting. These include the use of supplementary lighting, the seeing requirements of business machine operations, and the need of rational maintenance methods and programs.

7.2 — *Supplementary Lighting*

(a) In some cases local lighting is used to supplement general illumination. Additional or supplementary lighting may be used advantageously in conjunction with general illumination to provide footcandle values which are unattainable from general lighting or to compensate for losses due to the oblique position of the work (Fig. 55).

(b) Better posture and improvement in most seeing factors often result when office work is raised from the horizontal to some tilted or sloping position. A reduction in task brightness generally results since the illumination on horizontal planes is higher than that on planes more nearly vertical, but a net gain in visibility or ease of seeing is realized.

(c) Copies of invoices, lists, etc., which office workers must see in accurate detail, usually represent the most difficult seeing tasks in the modern office. The paper is often of poor quality and the printing almost undecipherable, especially on sixth or seventh copies, which are quite common. The contrast between the paper and the printing may also be very low. Such tasks impose undue stress upon seeing and require lighting values not practical with general lighting alone. In many cases, the work may require 100 footcandles or more.

(d) Care should be exercised to choose supplementary lighting units which will distribute the light uniformly over the working surface without objectionable direct or reflected glare in the eyes of any worker in the office. The supplementary lighting should not produce brightness ratios within the field of vision beyond the 3:1 limit previously designated.

(e) Detailed discussion of supplementary lighting principles may be found in the I.E.S. "Recommended Practice for Supplementary Lighting."

7.3 — *Office Machines*

The tasks involved in the use of business machines may be divided into three classifications.

7.3.1 — *Seeing the Work* — Seeing the work consists of reading printed, typed or written figures and words and is facilitated by proper positioning of the work and use of supplementary lighting.

7.3.2 — *Operating the Machine* — Operating the machine involves the use of various keys, buttons, levers and other controls. It does not present a difficult seeing problem since most of the motions are performed by the touch system.

7.3.3 — *Reading the Dials and Tapes* — **(a)** Bold, block numerals are recommended for machine dials. Dials should be kept clean to maintain maximum visibility and wherever possible, it is desirable to avoid the use of transparent window coverings. Initially, these coverings are shiny and cause reflected glare and, in time, become scratched so that the visibility of the dials beneath them is reduced. It would insure more rapid and accurate work if lighting and magnification were incorporated in business machines as has been done for some industrial equipment and commercial scales. There is some advantage in black figures on white dial backgrounds.

(b) Tape and other types of printing machines should be examined and properly maintained to get the greatest visibility possible. Type size should be large, but since it is usually fixed, full advantage should be taken of good white paper and solid, black impressions. Supplementary lighting, again, can often be used to advantage.

7.4 — *Maintenance*

(a) Lighting equipment and room surfaces must be well maintained if reasonable efficiency and satisfactory appearance are to be realized. The elements which affect the overall efficiency of a lighting system are the light sources, the luminaires and the room surfaces. Without a regular maintenance program, the illumination may be reduced to as low as one-half its initial level due to decrease of lamp light-output, and dust and dirt on luminaires, lamps, and walls.

(b) The output of all light sources diminishes with use and, in most cases, it is economical to replace lamps before they finally fail. With planned lamp replacement schedules, savings are realized by replacing groups of lamps rather than individual ones, and depreciated lamps are replaced by those of peak performance. Group replacement is based on the premise that the saving in cost of replacing lamps is greater than the value of the remaining light output in a large group of lamps after a certain number of hours of operation. A good plan is to group replace lamps after 20 per cent failures, and save the best 20 per cent for random replacement for the new group.

(c) Lamps and lighting equipment collect dust and dirt which reduce lighting efficiency. The rate of depreciation is dependent upon the atmospheric conditions and the type of lighting system employed. With proper cleaning schedules, an increase of at least 25 per cent is often realized in the average maintained value of illumination. Lighting units should be chosen with minimum depreciation characteristics and maintenance features in mind.

(d) The necessity for cleaning or painting room surfaces is also a function of the amount of dirt contained in the atmosphere. The rate of depreciation is materially reduced where air-conditioning and filter systems are employed. The distribution characteristics of the lighting system also influence the effect of room maintenance, since dirt on room surfaces is more detrimental to an indirect than to a direct lighting system.

(e) A regular program of window cleaning is also essential. Although

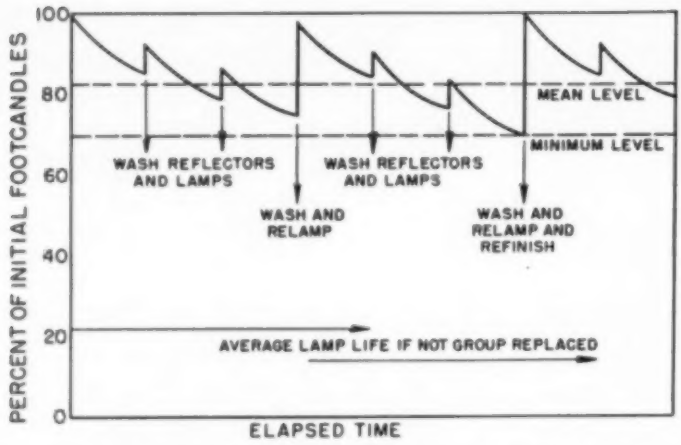


Figure 56. Suggested cleaning and maintenance schedule. Minimum and mean levels of illumination are less than initial. Lamp output depreciation and dirt on lamps, luminaires and room surfaces account for the losses. The amount depends on lamp type, type of units, the atmospheric conditions and the actual use schedule so that no single chart can do more than illustrate the principles involved. The frequency of the various maintenance operations will vary but their relative order of occurrence is as shown — luminaire washing, lamp replacement (best done on a group basis and coordinated with a washing operation) and cleaning and refinishing room surfaces.

the accumulation of dirt may not be as rapid in office buildings as in factories,* the windows require frequent washing to maintain them at reasonable efficiency. Dirt on the inside and outside of windows may absorb 15 to 20 per cent of the incident light. At the same time, the diffusing effect of such dirt can result in very high brightness at the windows and can produce serious direct glare. In modern offices windows are usually cleaned about once a month.

(f) A realistic consideration of these various factors is essential to the efficient operation of the office lighting system. The cost of planned maintenance is more than offset by the value of the additional illumination obtained.

Appendix A
Lighting Definitions and Nomenclature

A-1. — General

These brief descriptions and definitions have been extracted from the "Illuminating Engineering Nomenclature and Photometric Standards" Z7.1-1942 of the American Standards Association and the Illuminating Engineering Society. Many popular concepts as to the meaning and significance of certain illuminating engineering nomenclature are erroneous and lead to misinterpretation and improper application of lighting principles.

A-2. — Light

For the purposes of illuminating engineering light is radiant energy evaluated according to its capacity to produce visual sensation.

A-3. — Lumen

The lumen is the unit of luminous flux (or time rate of flow of light).

A-4. — Reflectance

The reflectance (or reflection factor) of a body is the ratio of the light reflected by the body to the incident light.

A-5. — Transmittance

The transmittance (or transmission factor) of a body is the ratio of the light transmitted by the body to the incident light.

A-6. — Illumination

Illumination is the density of the luminous flux on a surface; it is the quotient of the flux (divided) by the area of the surface when the flux is uniform over the area.

A-7. — Footcandle

The footcandle is a unit of illumination. It is the illumination on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illumination produced at a surface all points of which are at a distance of one foot from a uniform point source of one candle.

A-8. — Brightness (Luminance)

Brightness is the luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction.

A-9. — Footlambert

The footlambert is a unit of brightness (luminance) equal to one lumen per square foot and therefore is equal to the uniform brightness of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot or to the average brightness of any surface emitting or reflecting light at that rate.

(The average brightness of any reflecting surface in footlamberts is, therefore, the product of the illumination in footcandles and the reflectance of the surface.)

A-10. — Luminaire

A luminaire is a complete lighting unit consisting of a light source, together with its direct appurtenances, such as shielding media, reflector, refractor, housing and such support as is integral with the housing.

A-11. — Fenestration

Fenestration refers to any opening or arrangement of openings (normally filled with media for control) for the admission of daylight.

Appendix B

B-1. — Economic Factors

B-1.1 — Cost — The overall cost or expense for the lighting would include: (a) an amortization of the first cost, or Capital Expense, (b) the cost of the electrical energy consumed, or Energy Expense, (c) the cost of the lamp replacements, or Lamp Renewal Expense, (d) an estimate for Cleaning Expense, and (e) an estimate for Repair Expense.

B-1.1.1 — Form — The following form will be helpful in studying the expense analysis for one or more specific conditions:

B-1.1.2 — Determination of Factors for Form

B-1.1.2.1 — Installation Data — The installation data is taken from the plan which is under consideration for a given room or building.

B-1.1.2.2 — Capital Expense* — The complete cost of the installation (luminaires plus wiring) is obtained from a quoted price or a close estimate. The life of an installation is not fixed. In fact, because it may be desired to take advan-

*See Table 7-4, page 7-6, *I.E.S. Lighting Handbook*, Second Edition.

*An item listed as "Overhead Expense" is sometimes used including what is here shown as "Capital Expense," plus "Cleaning and Repair Expense." This may be found by adding to the Capital Expense, as here determined, interest on the complete cost at one-half of the probable annual rate because of the decreasing principal and an estimated amount of perhaps 5 per cent of complete cost to cover cleaning and repairs. This method is used for a quick estimate or where there are not sufficient data for the longer method.

Complete Expense Analysis.

General Information	Lighting Method #1	Lighting Method #2
Installation Data		
Type of Installation		
No. of Rows		
Luminaires per row		
Lamps per luminaire		
No. of lamps		
Watts per lamp (incl. accessories)		
Total Watts		
Maintained Footcandles		
Calculation of Complete Expense		
Capital Expense		
No. of Luminaires		
Estimated cost each installed		
Total cost luminaires		
Estimated wiring per luminaire		
Total cost wiring		
Total (luminaires plus wiring)		
Assumed years life		
Total Capital Expense per Year		
Energy Expense		
Total Watts		
Average Hours Used per Year		
Kwh per year		
Average Rate per kwh		
Total Energy Expense per Year		
Lamp Renewal Expense		
No. of lamps		
Avg. hours used per year		
Total lamp hours per year		
Rated lamp life in hours		
Avg. lamp renewals per year		
Net price each		
Replacement expense each (labor)		
Net price plus repl. expense each		
Total Lamp Renewal Expense per Year		
Cleaning Expense		
No. of washings per year		
Man-hours each (est.)		
Man-hours for washing		
No. of dustings per year		
Man-hours each (est.)		
Man-hours for dusting		
Total man-hours		
Expense per man-hour		
Total Cleaning Expense per Year		
Repair Expense		
Repairs (Based on experience, allocation of repair man's time, etc.)		
Est. Total Repair Expense per Year		
Recapitulation		
Total Capital Expense per Year		
Total Energy Expense per Year		
Total Lamp Renewal Expense per Year		
Total Cleaning Expense per Year		
Est. Total Repair Expense per Year		
Complete Lighting Expense for Year		
Complete Lighting Expense per Footcandle per Year		

tage of future improvements in lighting equipment sooner than the installation might normally be discarded, it is customary to assume 8 to 10 years, and to divide the complete cost by this figure to determine the annual capital expense.

B-1.1.2.3 — Energy Expense — The cost of electrical energy requires a knowledge of the local rate and an estimate of the hours the lighting is to be used as well as the total kilowatts for the area being lighted. Rates will vary with the geographical location and with the amount of use of energy. Multiplying the kilowatts by the hours by the rate will give the total expense for electrical energy.

B-1.1.2.4 — Lamp Renewal Expense — Lamp manufacturers publish the rated average life of their lamps. Multiplying the number of lamps by the average hours used and dividing by the rated life* will give the number of lamp replacements for the period under consideration. This multiplied by the net cost per lamp plus labor cost will give expense for lamp replacements for the period.

B-1.1.2.5 — Cleaning and Repair Expense — The procedure for estimating the cleaning and repair expense, where these values are used separately and not as a part of the overhead, is indicated in the form.

B-1.1.2.6 — Total Expense — Adding these several elements will give the complete lighting expense for the period assumed.

Appendix C — Wiring

C-1. — General

Adequate wiring is essential to good lighting. The wiring should have sufficient capacity to minimize voltage drop and energy loss. It must also be safe. These factors should be considered not only for immediate conditions but also for future demands.

C-2. — Reference

Suggested references on wiring are:

C-2.1 — National Electric Code

National Board of Fire Underwriters
85 John Street, New York City
222 West Adams Street
Chicago, Illinois
Merchants Exchange Bldg.
San Francisco, California

C-2.2 — Interior Wiring Design for Commercial Buildings

The American Institute of Electrical Engineers
33 West 39th Street
New York 18, New York

*Or the useful life if a group replacement plan is used.

A high-reflectance floor (60%) in this office "kicks back" light to the ceiling, further reducing brightness contrast of luminaire and ceiling surface (75%). Walnut walls have lower reflectance than recommended practice, but have been relieved over large areas by cove lighting, and illuminated murals, niches, and draperies. Four-foot plastic bottom fixtures, spaced 11 x 12 feet, are surface mounted on the 11-foot 10-inch ceiling in the center area. Each is equipped with six 40-watt standard cool lamps. At the sides of the room, two-foot square similar units (6 each 20-watt) are recessed, six feet on centers over the work edge of the desk.

Pendant pierced spun brass fixtures with 150-watt R-40 lamps highlight growing plants for decoration. Average level is 60 footcandles. Installation is the work of Miss Ruth Patterson, lighting consultant, Dallas Power and Light Co. Awarded third prize in the 1955 MMILJ contest, Southwestern Section.

mmilj

A winning factor in many a MMILJ contest has been adherence to the principles of recommended practice. Office lighting installations getting favorable votes of contest judges are shown on these pages.

In the re-do of an old-fashioned, awkward, L-shaped public utility office area, lighting and floor plan have been designed to complement one another. A free-form louverall drop ceiling using ¾-inch cube grates and outlined by neon-lighting coves around its perimeter, breaks up the office's former harsh rectangular look. The ceiling installation has 8-foot, 6-foot and 4-foot fluorescent strips above it on a two-foot spacing, using a 16 x 36-inch module, and furnishes a level of 90 footcandles maintained. To customers entering the office, the cashier receiving section is a natural focal point. Lighted shadow boxes and a silhouetted map of the state draw further attention to this section. Luminaires for all general and office areas are equipped with louver bottoms to match the grated ceiling. The installation, including other areas not shown, won second prize for Roger B. Cole, Jersey Central Power and Light Co., 1955 New York Section MMILJ.

Furniture and fixtures in this office are not brand new, but as far as the engineer was able, surfaces have been brought within recommended reflectance limits. Ceiling, 75% white perforated acoustical tile. Walls, light peach, 65%. Floors, buff asphalt tile, 35-40%. Desk tops, buff linoleum at 45%. Flush-mounted luminaires of two sizes of "panels" are on a diagonal pattern. Average maintained illumination is 70-75 footcandles. Entered by Robert B. Earl, of Earl and Gropp, consulting engineers, San Francisco, Golden Gate Section's 1955 MMILJ contest.

My Most Interesting Office Lighting Job

Functional lighting has been combined with an opportunity to display lighting principles in every area of the new building of Raybro Electric Supplies Co., Tampa. The area shown is one of the general offices. Customers tour the building to view fixtures types, and at the same time are exposed to interiors in which it has been the endeavor to embody recommended office lighting practice in all its aspects. A level of some 100 footcandles is achieved in this room, with high comfort resulting from planned adherence to brightness and surface reflectance limitations. Luminaires are in four continuous rows, 4-lamp, 8-foot glass shielded units, ceiling-mounted and functionally spaced in relation to desks. The installation was a joint entry of J. A. Savarese, Jr., Tampa Electric Co., and Raybro Electric Supplies Co., Tampa. Awarded first prize, Florida Section MMILJ contest, 1955.

Other Areas in Offices

Recessed louvered troffers provide 50 footcandles in mail room.

Single-lamp white enamel louvered units with luminous sides, using 96T12 cool white lamps, provide 50 footcandles in stock room (right). Fixtures are suspended in three rows 18 inches from the ceiling on 5-foot, 5-inch centers.

Twelve 2-lamp suspended louvered fixtures are mounted on 7-foot centers in mail and supply room, with resulting illumination level of 60 footcandles. Room dimensions are 40 x 20 feet with 10-foot ceiling.

- Washrooms
- Mailrooms
- Stockrooms

In good office lighting installations, these areas too are part of the picture.

Decor of this washroom should elevate its designation to "Powder Room." Mirrors are lighted by ten built-in strips shielded with Alba-Lite glass. Upward light from the spun brass center fixture furnishes approximately 25 footcandles of general lighting.

Two 2-lamp units using 40-watt T12 rapid start fluorescent lamps over this mirror furnish 100 footcandles at face level. In the ceiling are 2-lamp troffers with Alzak louvers.

Two-lamp corner units have been mounted the entire length of one wall over the plumbing fixtures in this men's washroom. Mirror brackets light each wash basin. No ceiling lighting.

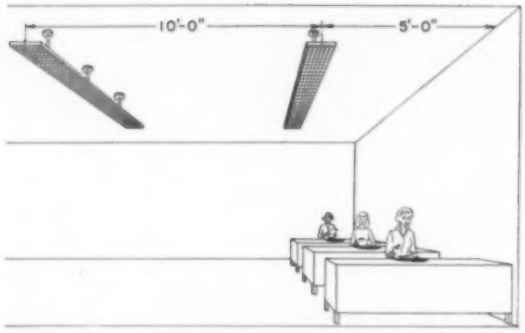


Figure 1. Where desks are against an end wall, the recommended spacing of "half the distance between luminaires" can create an undesirable shadow condition.

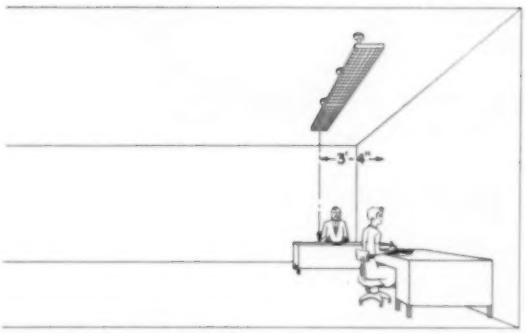


Figure 2. The "one-third spacing" rule too can result in shadow conditions with some placements of furniture and equipment. Note worker in her own shadow.

Luminaire spacing from side and end walls can seriously affect results in an office lighting system. This article offers suggestions for such spacing, for direct, semi-direct, semi-indirect and general diffusing lighting systems for offices, providing a bench mark as another step forward in office design.

Luminaire Spacing . . .

SPACING of luminaires from the side and end walls of an office has often been of concern to the lighting engineer, and, of course, to the office personnel working under these lighting fixtures.

Our practice in this connection has been guided by the recommendation in Section 9, page 17, of the *IES Lighting Handbook,* Second Edition.

"The distance between luminaires and the wall should not exceed one-half the distance between luminaires. Where desks or benches are along the wall, the distance between luminaires and walls should not exceed one-third the spacing between luminaires. Where direct and semi-direct luminaires are used under such conditions, the perimeter of luminaires should be carefully located to avoid shadows on the work from the worker."

To consider the first part of the statement, *"The distance between luminaires and the wall should not exceed one-half the distance between luminaires,"* this specification means that with luminaires spaced ten feet on center, the luminaire spacing from side walls should be five feet. This spacing recommendation, however, is often applied to offices before the layout of office equipment is known. Fig. 1 is an example of what could happen to this specification with desks located on the end walls. Notice how shadows on the work surfaces are caused by this relation of luminaire-to-working-surface.

The balance of the recommendation, taken literally for all circumstances, also has pitfalls. *"Where desks or benches are along the wall, the distance between luminaires and walls should not exceed one-third the spacing between luminaires. Where direct and semi-direct luminaires are used under such conditions, the perimeter luminaires should be carefully located to avoid shadows on the work from the worker."* Assuming a ten-foot spacing between luminaires, one third of this spacing is three feet four inches from luminaire to wall. With some placements of furniture and equipment, this spacing also causes shadows (see Fig. 2).

I quite agree with the statement: *"Where direct and semi-direct luminaires are used under such*

AUTHOR: Detroit Edison Co., Detroit, Mich.

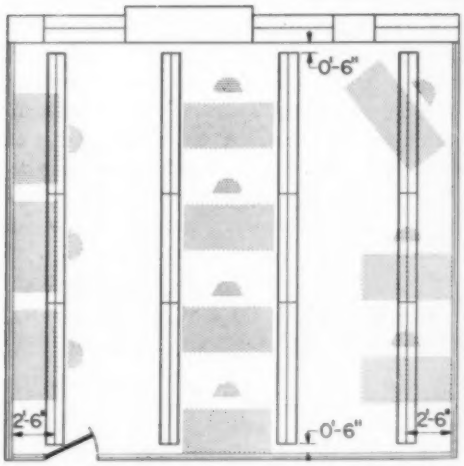


Figure 3. Spacing of fixtures 2 feet 6 inches from wall permits orientation for best seeing conditions.

Figure 4. With end of desk against wall, luminaire spacing of 2 feet 6 inches from the wall centers the fixture over the work. Note uniformity and absence of shadow.

for End and Side Walls

By JAMES F. FINN

conditions, the perimeter luminaires should be carefully located to avoid shadows on the work from the worker." However, direct-indirect and general diffuse luminaires should also be included in this category. In order to assure proper location of luminaires adjacent to side walls, the following specific lighting recommendations are offered:

Spacing between luminaires and wall should be two feet six inches.

This spacing permits rearrangement of desks with maximum utilization of illumination. For example, the conventional desk is five feet long, by two feet six inches wide. Therefore, in an application where desks are placed against the wall, with

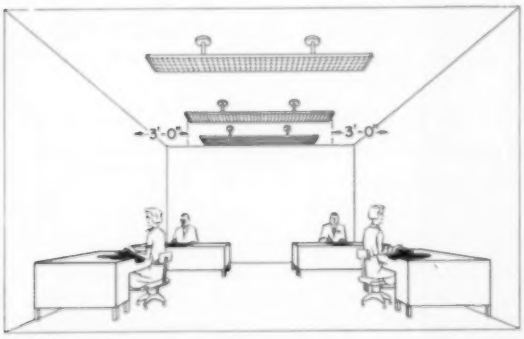


Figure 5. Improper distribution of light to work task results with the luminaire spacing and desk orientation as is shown here.

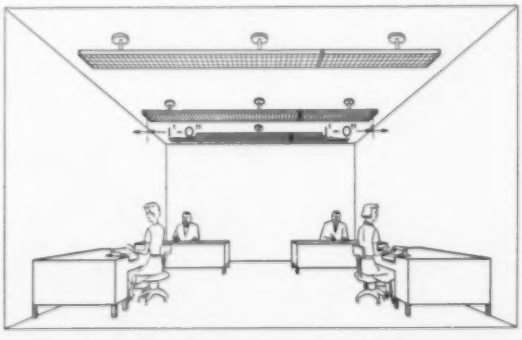


Figure 6. Ends of luminaires should be spaced as close to walls as possible. Suggested spacing will provide more uniform illumination on task, and minimize shadows.

the person performing the work facing the wall, the luminaires spaced two feet six inches from the wall would be centered over the leading edge of the desk. (See Fig. 3, left-hand row.) Overhead luminaires would not be seen at normal scanning angles. Luminaires that are spaced farther than two feet six inches from the wall cause shadows on the work, since the light source is to the rear of the person performing the task.

Where the end of the desk is faced against the wall, a luminaire spaced two feet six inches from the wall would be centered over the desk. (See Fig. 3, right-hand row, and Fig. 4.) Notice the absence of shadows and uniformity of illumination.

Another very important factor in distribution of illumination on the work surface which has not been clearly defined in our past office lighting practice is the need for specifying that the end of luminaires be spaced as close as possible to walls. Fig. 5 illustrates another example of improper distribution of illumination. The new Office Lighting Practice specifies preferred spacing between end of luminaire and wall.

Illustrated in Fig. 6 is a suggested endwise spacing which will provide not only more uniform illumination on the work task, but a minimizing of shadows as well. This can be accomplished by spacing ends as closely as possible to the wall, i.e. six inches to one foot. In no case should the dimension exceed two feet from the ends of the luminaire to the wall. Spacings closer than six inches may result in light scallops on the wall and/or prevent the removal of the luminaire end plate for servicing.

The basic lighting plan for office lighting should be a design that will include proper spacing of luminaires to provide a pattern of lighting, to fit any arrangement of office desks and equipment.

Photo courtesy General Electric Company

Desk and Drafting Board Lighting

Six-lamp louvered fixture is built into a wooden grid framework and provides about 100 footcandles on the desk and drawing board. Supplementary lighting over the board, and also over the drawing file cabinet, is reflected back from the light walls.

Esthetics of Office Lighting Layout

By GEORGE P. WAKEFIELD

Esthetics in an office is a controversial subject. Few people can agree on what it constitutes — or even how to spell it! How to recognize its elements — how to apply them — are offered in this article.

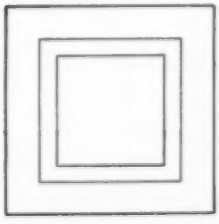
ESTHETICS of lighting layout is not too difficult to comprehend if a simple definition is established for "esthetics." In lighting design, it simply means—the pleasing arrangement of lighting elements—or if you wish, a pattern designed by skilled or experienced eyes. Anyone can attain some degree of this skill after a number of trial layouts. There are few mysteries of any great importance to discourage the layman. Generally, such physical problems as outlet boxes available, or beams in the way, influence the end results more than esthetics.

Nevertheless, lighting can be laid out in varying degrees, from poor to good, with the sole difference coming from the use of skill, or "esthetics." We're talking of a subtle factor not usually noticed by office occupants, but one readily visible when viewed comparatively.

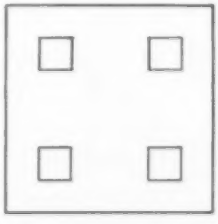
We have now simplified our problem but have admitted that things could be better with the artist's touch. That's our subject: how to make layouts better by the use of logic and a few basic rules of art. These rules can be applied directly while making the layout drawings, and will result in a better interior appearance, an atmosphere of neatness, and a reduction of monotonous effect. It may even result in an environment more conducive to work.

Recessed or On-Surface Luminaires

Suppose we start with a small, square room. This room suggests a square or matching layout. It could be attained with a hollow square of rectangular luminaires and the use of four square luminaires, thusly:



1



2

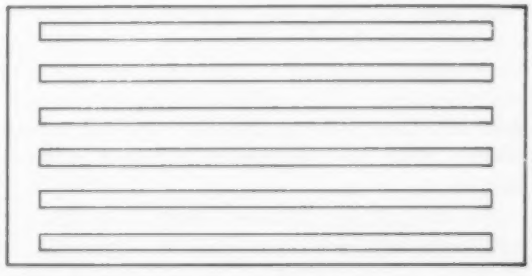
AUTHOR: Architectural Development Dept., The Wakefield Company, Vermilion, Ohio.

Round luminaires would go well, but since they are not generally considered commercial fluorescent units, we do not show them. We are applying recessed and surface-mounted fluorescent luminaires, in these cases. If larger areas take a square form from exposed beams, the above "matching" rule may apply.

Now, let us continue with a different room shape. Rectangular rooms are very common and lend themselves readily to standard luminaire types. Obviously a rectangular form is suggested.

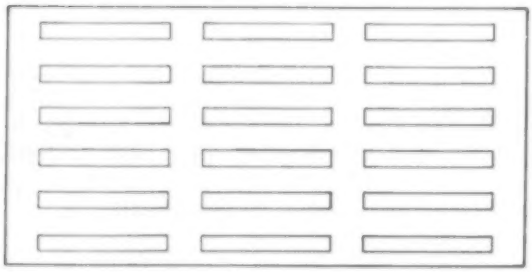
3

Nothing could be easier or esthetically much better. However, if you extend the room and continue the rows of luminaires, you provide a monotonous feeling. Like this:



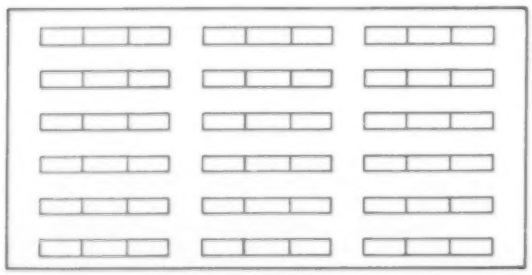
4

Pleasant breaks are suggested to stop the eye from rushing to the end of the room. Such breaks may appear in this next form.



5

If the luminaires are of the individual type when placed end to end, use them in rows of three or five, not two or four. Like No. 6, below.



6

The use of three or five can best be explained by the symmetrical balance provided by the central unit. The eye rests on the second or third luminaire, rather than shifting back and forth between two, or the two pairs of four.

The matching rule as applied in square and rectangular rooms may be repeated in larger areas of square or rectangular components.

Suppose, however, your interests are aimed at shortening the apparent length of a long room. Your esthetic training in this case must be discarded in favor of an optical illusion. This is still good taste and a sound functional use of layout design. Run the rows crosswise with suitable breaks.

The use of air diffusers along with lighting equipment may cause some problems. Generally, it is well to run the diffusers into the rows in some neat arrangement. This, of course, requires square or rectangular air diffusers, which are available. An interesting and less monotonous grouping could come from the use of round diffusers spaced appropriately between the luminaire rows.

Exposed grid ceilings (non-luminous) can be monotonous. The use of offset rectangle patterns may be helpful in correcting this disturbance. Massing the luminaires will add interest and reduce sameness. Round air diffusers provide excellent relief with these ceilings.

Modular luminaires are certainly a necessity in exposed grid ceilings. Air diffusers are considered useful esthetical accessories solely because of their anti-monotonous contribution to design.

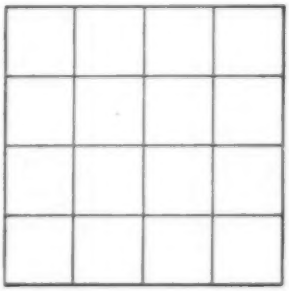
Large areas have the prime characteristic of perspective that in itself tends to obliterate the theme of sameness from the ceiling pattern. This effect is not noticeable from a reflected ceiling plan of a drawing. Possibly this is a favorable ally to design in large areas.

The final layout of ceiling grid, luminaires, or air diffusers, should command proper trial and study as this area represents the major casual view in an interior. It has the dominant atmospheric role to play.

Luminous Ceilings

Such areas should be designed with even greater skill than the luminaire type ceiling because of the larger luminous areas involved and higher apparent brightness contrasts displayed. The accent of line in the luminous pattern is considerably more effective. Lines must run straight and true and must have either end on a vertical line or between two vertical lines. Modularity and coordination is a must in luminous ceilings. There is little room for error, just enough for normal building tolerances.

Suppose we take a square room and lay out a cross grid system. Such as this:



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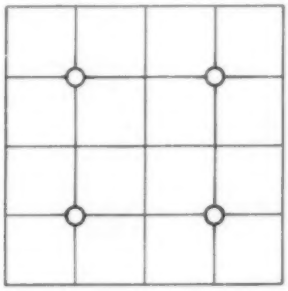
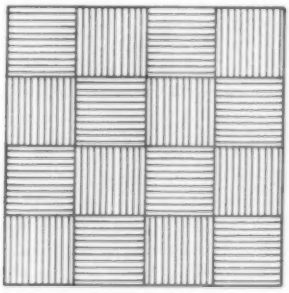
Suitable, one might say, based upon the matching rule. The trend is to monotony, however, as you can see. Our air diffusers could come to the rescue by changing the tempo, like this:



8

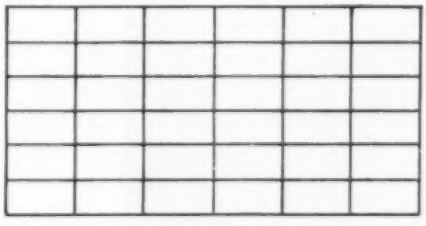
Another feature would be the variation of the luminous panel texture or direction:



9

Luminous panels may be alternated with louver panels in a fitting manner. Color used in the luminous panel has possibilities as another media of change. One definite characteristic of the luminous ceiling is its dramatic and effective impact upon the feeling of the room. This, of course, is why we propose care in layouts.

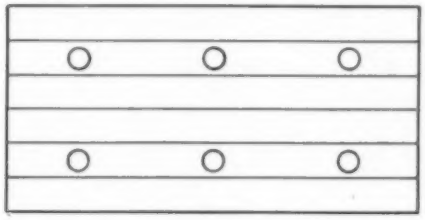
A rectangular room suggests a rectangular panel and grid running with the room. Like this:



10

Similar modifications with air diffusers and panel textures may be added for more interest. The illusion of a shorter room could be featured by running the long dimension of the panel crosswise.

In parallel grid patterns for rectangular rooms, air diffusers may be used nicely in the luminous panels in this manner:



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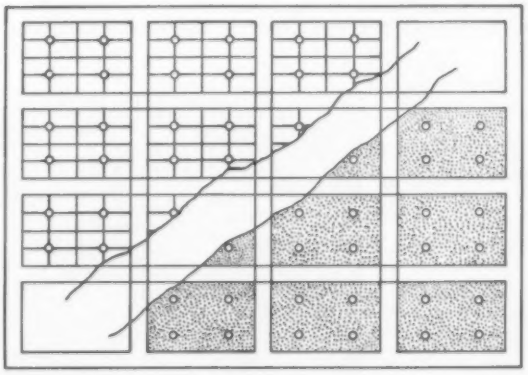
Such a scheme also provides simple installation by keeping the air diffuser clear of the luminous ceiling grid. The parallel grid allows the air diffuser to stay free from the grid as in contrast with the square grid in a square room where the intersection of the grid demands the air diffuser.

In large areas where exposed beams provide a functional ceiling design, it is usually good practice to preserve the beam effect, thereby dividing the large luminous areas into smaller ones.



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A room of this sort may require a gridless luminous ceiling rather than an exposed grid type due to the feeling of too much grid.

Large areas of luminous ceilings can be broken and shielded by partitions or cross tees. Interesting patterns can be provided by choosing a suitable texture, either of the grid or the luminous panel. The wise location of air diffusers can add

greatly to the large areas sameness. The complete elimination of the grid alotgether seems in order in some cases.

One area of interest in which the luminous ceiling has recently entered is in the exterior or street view. Large luminous areas completely fill the fenestration providing very unusual daytime or night-time effects for buildings. This feature entails consideration of the luminous ceiling from without for details of texture, pattern, and coordination of modules.

Odd shaped areas with angular or curved sides may require special consideration of the grid design. They may also appear better with a gridless texture, minus the directional lines of a grid.

One other rule seems to have made itself apparent in the luminous ceiling saga. That is — lamps should not be visible, and vestiges of beams or ducts should not show. In other words, one does not expect them to be visible. Hence they should not be. This is a good rule and will provide safe guidance and protection from a barrage of after-installation questions.

Good engineering is not in itself sufficient for a pleasing interior. Good engineering plus the artist's skill is essential. On the other hand, some of the artist's skill can be classified to be used by the engineer, allowing him to make office lighting layouts suitable for most esthetics, and no doubt, the average office inhabitant.

Troffers in a General Office

General office is 24 by 160 feet in area with a 10-foot ceiling. Rows of single-lamp recessed troffers containing one 8-foot and two 6-foot slimline lamps, on 200 ma, are spaced on 3-foot centers providing an average of 55 footcandles. The units are equipped with baffles on 6-inch spacing. For more even distribution near the inside wall, an additional row of troffers is located perpendicular to the cross rows. Walls are light gray, floor is light tan. Installation is of T-bar construction with the acoustical ceiling hung on the fixture.

Photo courtesy General Electric Company

Luminous Ceiling—With Mercury

By J. B. BROWDER
J. E. SWEATTE

In addition to the basic quantity and quality requirements, five factors influenced our choice of lighting design in re-lighting this private office. These were:

(1) Ceiling height of 18 feet. The 14 by 16-foot office is partitioned off from a larger area.
(2) Initial cost, including wiring.
(3) Maintenance.
(4) Any necessary change in existing air-conditioning ducts.
(5) Noise level in the comparatively small area.

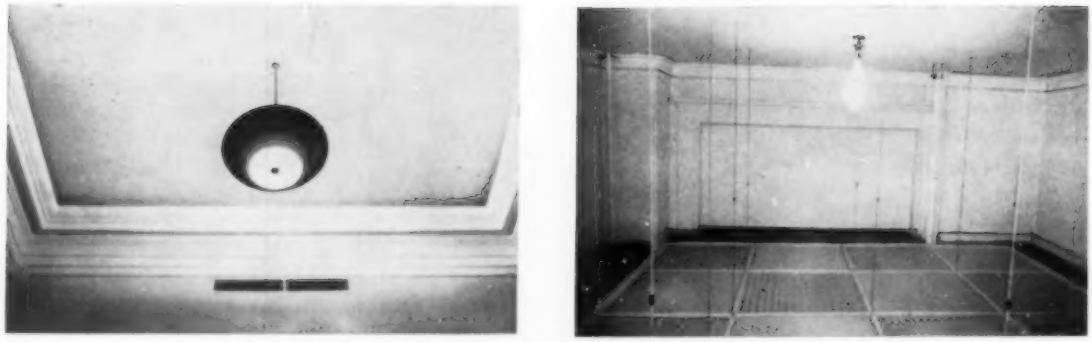
Authors: Commercial Sales Engineering Division, Georgia Power Co., Atlanta, Ga. This installation was entered in the Georga Section's 1955 contest for My Most Interesting Lighting Job.

The 18-foot ceiling height suggested the advantages of a luminous ceiling, and such a system was chosen. Vinyl plastic, in 3-foot-square panels, was mounted at a height of 11 feet 6 inches, leaving a 6-foot 6-inch plenum above.

As the light source a single 55,000-lumen color-corrected fluorescent mercury lamp was mounted in a porcelain socket in the existing ceiling outlet.

Quantity and Quality

The primary requirements of quantity and quality, of course, we checked first. After three months of operation average illumination at working level was over 50 footcandles, as measured with a cosine-



Existing outlet, used by incandescent luminaire in "before" photo (left) is utilized by the mercury lamp shown (right) in the 6½-foot deep plenum.

and color-corrected high-sensitivity light meter. our reading on the desk top was 60 footcandles.

As for quality—average brightness of the ceiling is 128 footlamberts. We had feared that, with a single light source, there might be a "hot spot" on the plastic ceiling. We found, however, that if one is there, it cannot be detected by the eye, or by the camera as is evident from the photo.

Other Considerations

With the "Q and Q" factors satisfactory, we next checked off against our list of other considerations.

(1) Ceiling height has been effectively lowered to 11 feet 6 inches.

(2) By utilizing the existing outlet, initial installation costs included removing the old luminaire, replacing it with the porcelain socket and dropping down from the existing lighting panel to the ballast in the basement and returning to the lighting panel. The existing branch circuit was used as the secondary of the ballast to feed the lamp. Fortunately, the existing wiring in this area provided one branch circuit for each outlet. Total cost of the installation by a local contractor was less than two dollars per square foot

(3) Replacement of the single lamp involves removing only the one plastic panel directly under it. Use of a street lighting lamp stick facilitates lamp replacement by one man from the floor.

(4) No changes were necessary in the air-conditioning system. The duct, now located in the plenum 4½ feet above the plastic ceiling, fills the plenum with cool air which filters through especially designed holes in the edge of the plastic to the working area. In operation we found this highly satisfactory.

(5) The remote location of the ballast, in the basement, eliminates any ballast noise in the office area. Other advantages of this location are the savings on re-wiring and on air-conditioning, without the additional load of ballast heat.

The final test of any job is "how does the user like it?" The user in this case is well pleased with the lighting in his private office — that of C. M. Wallace, Vice-President in Charge of Sales of the Georgia Power Company.

Register Early for
The Golden Anniversary Conference

Registration blanks for the National Technical Conference of I.E.S., to be held in Boston, in September, will be mailed to all Society members during June. Register early for this 50th Anniversary Conference.

Visibility of Office Tasks

By W. S. FISHER
H. M. SCHMIES

OFFICE WORK is seeing work. Almost every productive task in an office is performed or guided by human eyes. And, since seeing is a complicated process, all sorts of factors may influence how well and how easily we see.

A high order of task *visibility* is needed before we can see with ease. Task visibility is influenced by the size and contrast of details of the task and by the level of illumination provided. It may also be influenced by the length of time the task can be viewed, but, since the tasks studied in this paper were stationary objects, the time may be considered long enough to be eliminated as a factor of influence. However, speed of seeing is of concern to the employers of office workers as it may well affect the total amount of work performed per employee per day.

Because it is desirable for employees to see their work clearly, quickly, and easily, the characteristics of office tasks which affect visibility are important. The authors have made a study of the visibility of a number of tasks commonly performed in offices and drafting rooms. These findings are reported in this paper.

The measurements of visibility were made under carefully controlled laboratory conditions using a Luckiesh-Moss visibility meter and the test procedure described in a previous paper.[1] Twenty footcandles of well-diffused illumination was provided on the surfaces of the tasks which were viewed at a test distance of 14 inches. Visibility data obtained for the tasks were related to equivalent sizes of Bodoni Book Monotype.[2] This permits comparison with previously published information on the visibility of school tasks.[3] Future studies of additional tasks may also be readily compared with those reported here.

Typing

Some extensive studies were made on typing. A number of white bond papers suitable for originals of letters were selected for testing. These were the products of several paper manufacturers. In addition, a number of new black typewriter ribbons with various degrees of inking were tested with the bond papers. Cotton, silk and nylon ribbons were included.

A standard test paragraph was typed on each of the paper samples with each of the ribbons. The paper-ribbon combinations produced over one hundred test samples. An electric typewriter of modern design with Elite type was used for the typing in order to insure equal pressure on each key stroke. Elite type, while somewhat smaller than Pica type, is more popular as indicated by present-day typewriter sales. From all of these samples a best paper-ribbon combination was selected as the basis for further tests. The same paper was also used in the handwriting tests.

The reference black cotton ribbon had a high thread count (320 per inch) with medium heavy inking. Silk and nylon ribbons with the same inking showed visibility equal to that of the best cotton ribbon.

The visibility of black typing on paper, both white and colored, appears to be directly proportional to the reflectance for the range of papers tested. This is shown in Fig. 1. It suggests the use of good white paper for most office communications and forms. If color is needed for coding or

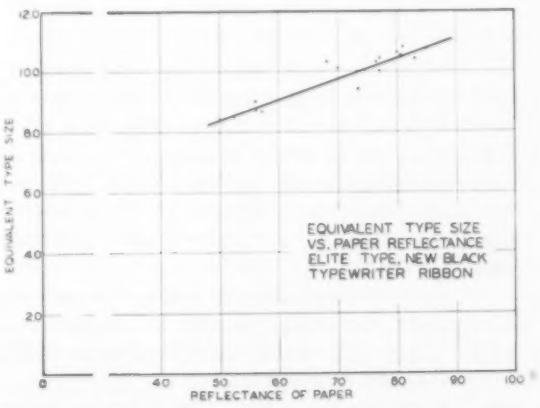
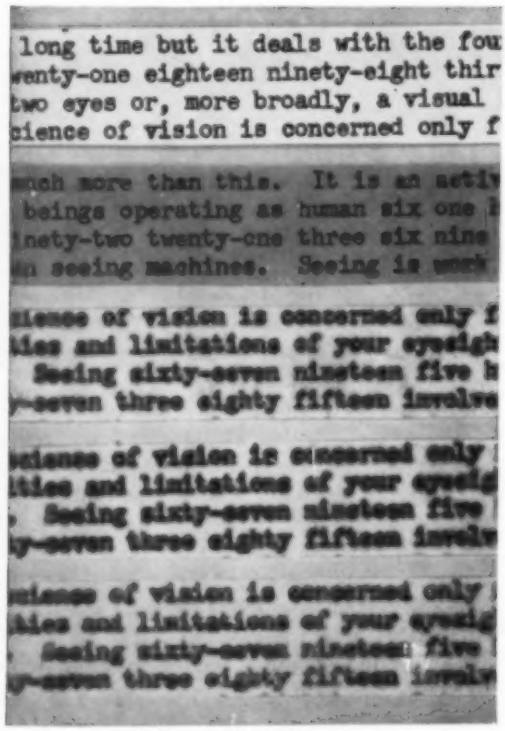


Figure 1. For the range of reflectances observed, the visibility of black typing appears to be directly proportional to the paper reflectance.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHORS: General Electric Co., Lamp Div., Cleveland, Ohio.



1. Twelve Point Bodoni
2. Nine Point Bodoni
3. Nine Point Bodoni
4. Eight Point Bodoni
5. Seven Point Bodoni

Figure 2. Change in equivalent type size for several typing conditions: (1) New black ribbon, 81% reflectance white paper, 12-point Bodoni; (2) New black ribbon, 57% reflectance pink paper, 9-point Bodoni; (3) First carbon copy, two copies made, 9-point Bodoni; (4) First carbon copy, six copies made, 8-point Bodoni; (5) Fifth carbon copy, six copies made, 7-point Bodoni.

identification purposes, very light tints should be used. From the standpoint of visibility, an even better practice for color identification is to use it only on the top or corner of a page which permits applying the main copy to white paper. The two top examples of Fig. 2 illustrate the importance of paper reflectance in the visibility of typed originals.

All testing of typed paper was performed with an opaque background having a reflectance of about 60 per cent. It was felt that persons reading both original letters and carbon copies would normally back them up with a light surface since it increases the apparent reflectance and improves visibility. The average reflectance of several sheets of typed originals and copies arranged in random order was determined to be about 60 per cent. This might be a typical background against which typed letters are read in an office. At a later time it was determined that the typical reflectance of the surface paper used to cover many drafting boards was also about 60 per cent in service. Therefore, the same background was used in the analysis of visual tasks involved in drafting.

A variety of carbon papers having different weights and finishes was also appraised and a reference carbon paper was selected for further testing. Fig. 3 indicates the reduction in equivalent type size for the reference carbon paper as it is re-used a number of times. A visual appraisal of typed copies indicated that appearance became a factor, at least as quickly as reduced visibility as carbon paper is re-used. It appeared from our tests that carbon paper might typically be used about twelve to fifteen times after which it is generally unsuitable.

The number of carbon copies made at one time also had an effect on visibility. This is illustrated by the three lower samples of Fig. 2. When two carbon copies were made, the first had an equivalent type size of 9-point Bodoni. When six copies were prepared, the equivalent type size of the first copy dropped to 8-point. The difference is accounted for by the cushioning effect of more copy papers and carbon sheets. This broadens the area over which carbon is applied and does not permit as clear, black letter strokes as with a few sheets between the typewriter key and platen.

It has been conservatively estimated that the

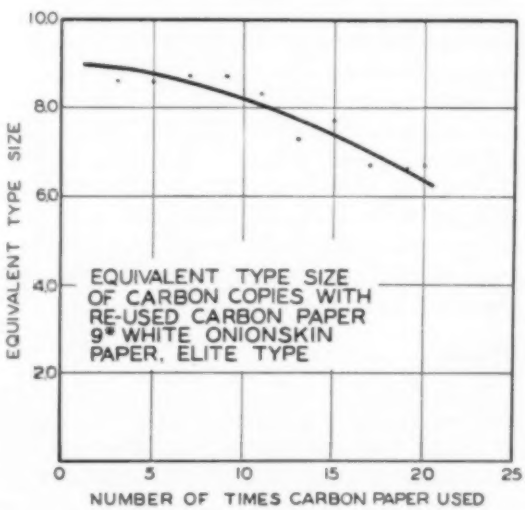


Figure 3. Visibility is reduced as carbon papers are used many times.

cost of preparing a typical letter is about one dollar. The largest items in this figure are the times of the dictator of the letter and the stenographer. Materials account for less than two cents out of the total. The additional cost, if any, of materials which provide a near-maximum visibility is insignificant compared with the total cost of the letter or to the probable worth of the improved appearance and ease of seeing.

Handwriting

The handwriting tests were performed principally on the reference paper of the typing test with a number of instruments. The results with black pencil are as expected with No. 1 providing best, No. 3, poorest visibility. The No. 2 pencil, which lasts longer and holds a point better than No. 1 lead, is an excellent choice for most conditions of use as the indicated result is just a half point smaller in type size than the No. 1.

Our tests showed that ball point pens with black or blue cartridges are about equal to No. 2 pencils in visibility. Samples of handwriting were observed under a microscope which revealed that the letter strokes made by fountain pens covered the paper with a smoother, more opaque stroke than pencils or ball point pens.

An interesting sidelight on the visibility of writing with ball point pens was found in samples prepared on ruled paper pads. Here the sheets of paper behind the top sheet acted as a cushion to surround the spherical pen point, permitting broader and better filled-out letter strokes than samples prepared on a single sheet with a hard backing such as a desk top. Pencils and fountain pens did not exhibit this characteristic to any marked degree.

Ruled papers and printed forms meant to be filled in by hand provide a definite amount of space for the writing. When the space allowance is small, the size of handwriting is restricted and visibility is reduced. Many of the printed forms tested had severe limitations on space which produced type sizes for the writing on them considerably lower than those reported for handwriting on the reference paper where space was not limited. This suggests that business forms be designed with considerable care to allow adequate space for writing. Well-planned forms can be processed quickly with less possibility of error than small, cramped designs. The bookkeeping ledger of Fig. 4 shows how visibility is reduced as two entries are inserted in space planned for one.

The test distance used for all visibility measurements in this study was 14 inches and the equivalent type sizes in the table are effective for that distance. However, there are many visual tasks performed in the office where the viewing distance is greater than 14 inches and the task is viewed at an angle from the normal. For example, it was found in a survey of the transcribing habits of about twenty stenographers that the average viewing distance for their shorthand notes was 21 inches. In addition, about half of them laid their notebooks flat on the desk where the viewing angle was about 45° from the normal. This combination of distance and angle can reduce the effective type size by nearly one-half (from 6.0 to 3.5 point for one example reported in the table). The transcribing of notes is one of the most common office tasks and a difficult visual one at best (See Fig. 5). The use of raised copy holders which position the work so that full visual size is presented can make the performance of this task easier and more efficient. Even though the illumination is usually less on vertical and slanting surfaces than on horizontal ones, there is usually a net gain in visibility. Supplementary lighting for the raised copy would provide additional benefits in visibility.

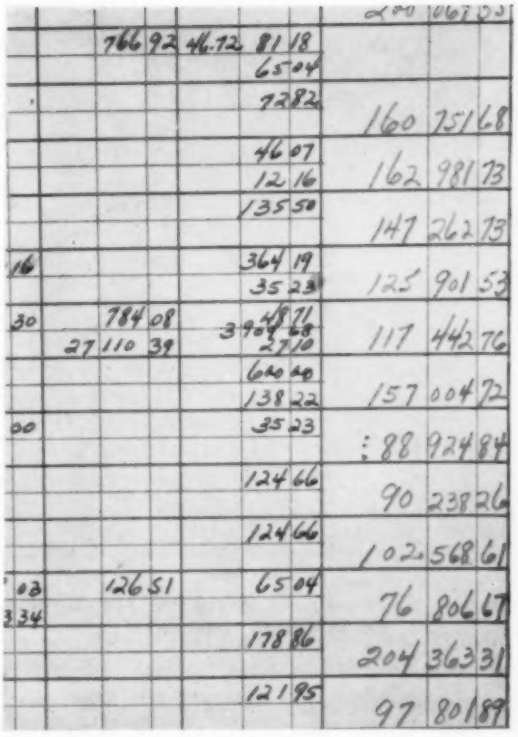
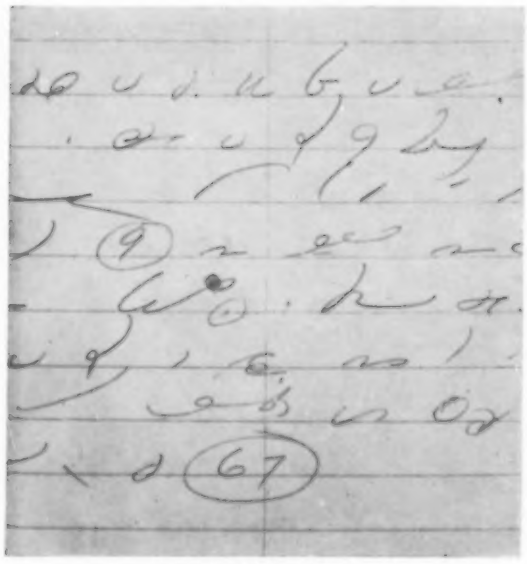


Figure 4. Hand-posted ledgers with clear, inked figures can be equal to 7-point Bodoni. Where small figures are inserted, equivalent type size can drop to 4-point.



Five Point Bodoni

Figure 5. Shorthand notes, written with #3 pencil here, can be difficult visual tasks.

Duplicated Material

Several reproductive processes were studied, some involving the preparation of stencils and masters, others producing copies directly from originals. For those processes which reproduce from the originals, one test objective was to make comparisons between the original and the copy when expert techniques were employed to produce the best copies inherent in the process. For most processes, this involved negligible loss in visibility after reproducing. (See Fig. 6.) Indeed, for some there was a measurable gain, as contrast between paper and a pencil line of moderate stroke, for example, can be enhanced in a reproduction by proper control of exposures.

For the processes involving stencils or masters, the skills of experienced people were employed to turn out duplicated material having good visibility. However, the skill and experience needed to produce duplicated material of good visibility may not always be available or employed, and often material is encountered which is poorer than that reported as typical in this table. To give some idea of what can happen in this situation, readings of a few materials which have been poorly reproduced are also included in the table.

The materials of some of these processes are subject to fading with exposure to light and/or time. Spot checks on a few samples were made which indicated perceptible fading and reduced visibility after a few weeks' exposure on a desk top. The limited data collected on this subject were not included in the table. However, if the preservation of visibility through an extended period of time is important, this factor may influence the choice of duplicating method.

The stencils commonly used for many office duplicating tasks are made in several colors other than the dark blue which has been commonly identified with this process. In general, stencil visibility is of a lower order than that of offset and hectograph masters which are prepared with inked ribbons on near-white paper. However, stencil manufacturers also provide "cushion sheets" in contrasting colors which may be inserted back of the stencils to give considerably improved visibility. The highest visibility observed was a yellow stencil with a black insert sheet. (See Fig. 7.) The use of color to provide more contrast is especially helpful for typewriter-cut stencils which are often proofread in the machine. A luminous panel for transillumination will provide much improved visi-

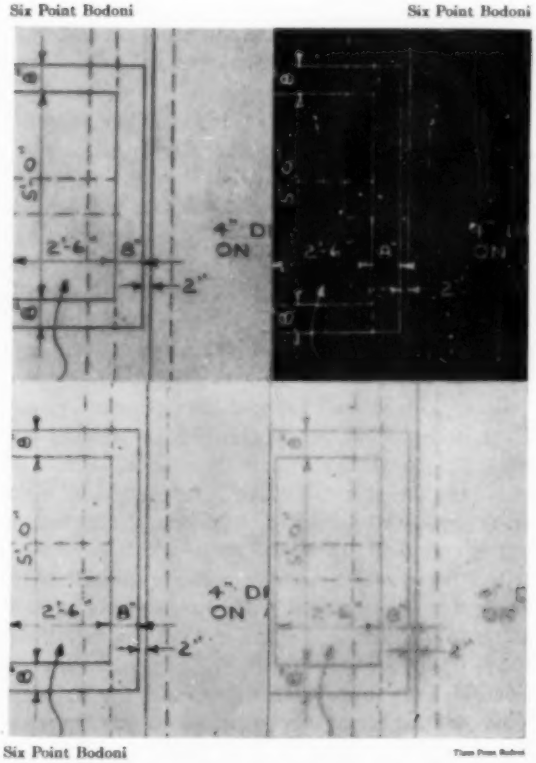


Figure 6. Skill in copying processes can reproduce visibility inherent in original, upper left, as seen with black and white reproduction, lower left, and blueprint, upper right. Even best tracing papers reduce visibility substantially, lower right, suggesting need of luminous panel for transillumination.

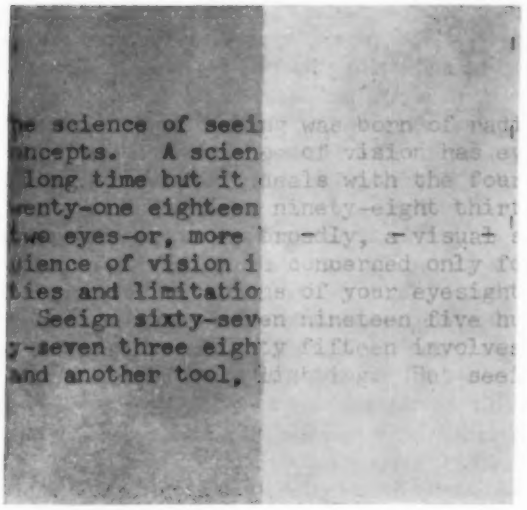


Figure 7. Typed yellow stencil with black cushion sheet is greatly improved in visibility over that cut with clear plastic cushion sheet.

bility for preparing stencils which are cut with a stylus and for proofreading stencils after they are removed from a typewriter.

Printing

A variety of printed material was examined. The equivalent type sizes reported in the table for this category do not necessarily correspond with the physical sizes of the type used in the various samples. In most cases the equivalent size was less than the physical size. This difference may be accounted for in the specific configuration of the type (which may be different from the Bodoni Book Monotype), the reflectance of the ink and paper, the opacity of the paper, and the "show-through," if any, of ink from the back side of the paper.

The "visibility" found for the printed samples is not an entire measure of their "readability." Other factors such as the length of a line of type, and the leading between lines influence the ease of reading. This subject has been covered in other literature.[2]

Drafting

Close attention to fine detail for prolonged periods of time characterizes the job of drafting. In recognition of this fact, the amount and quality of illumination provided for drafting areas is usually given careful consideration.

For the tests on drafting tasks a good many drawings, both old and new, in pencil and ink, on cloth and paper were selected from the files of an architectural engineering group. Most of the drawings exhibited both small and large detail, and several readings of visibility were made on each. As with printing and handwriting, the contrast of a letter stroke against its background is a prime factor in visibility. This places drawings done in black ink somewhat ahead of penciled drawings for similar papers or cloths. After an analysis of the preliminary data on drawings, a few were selected which were representative of the group and further tests were made with these originals and with blueprint and black and white reproductions made from them.

One typical draftsman's job is that of making a tracing from an original or reproduction. One of the tracing papers tested, having a transmission of about 50 per cent, reduced the relative visibility of an original by about one-half. (Equivalent type size reduction was from 6.0 to 4.0). Other papers typically reduced the relative visibility to 35 or 40 per cent of that of the original.

One efficient means of improving the visibility of tracing tasks is transillumination. (Lighting from overhead could provide a similar increase in visibility if enough illumination were supplied.) For the original drawings tested, a maximum relative visibility was reached when the background was between 100 and 200 footlamberts in brightness. The blueprint and black and white papers which were thicker and had a lower transmission than the originals continued to receive increases in visibility as the background brightness was stepped-up to 300 footlamberts. At this value they had a high, though not maximum, relative visibility. The difference in brightness needed for the thin originals and heavy reproduction papers suggests that the lamps in luminous panels be operated on two circuits or with fluorescent dimmers.

The equivalent type size reported for transilluminated drawings was measured with the test room lighting of twenty footcandles operating. Without the room lighting the visibility was noticeably lower. The 75 to 100 footcandles of illumination commonly provided in drafting rooms today contributes importantly to the visibility for tracing tasks. General room illumination also adds significantly to visual comfort for anyone working at a luminous panel by increasing the brightness and reducing contrast in the surround.

As a matter of interest, Fig. 8 was prepared according to methods outlined in an earlier publication.[4] It shows the illumination required for equal visibility of some of the tasks reported in this paper. The reference condition was arbitrarily selected to be typical typing (equivalent to 9-point

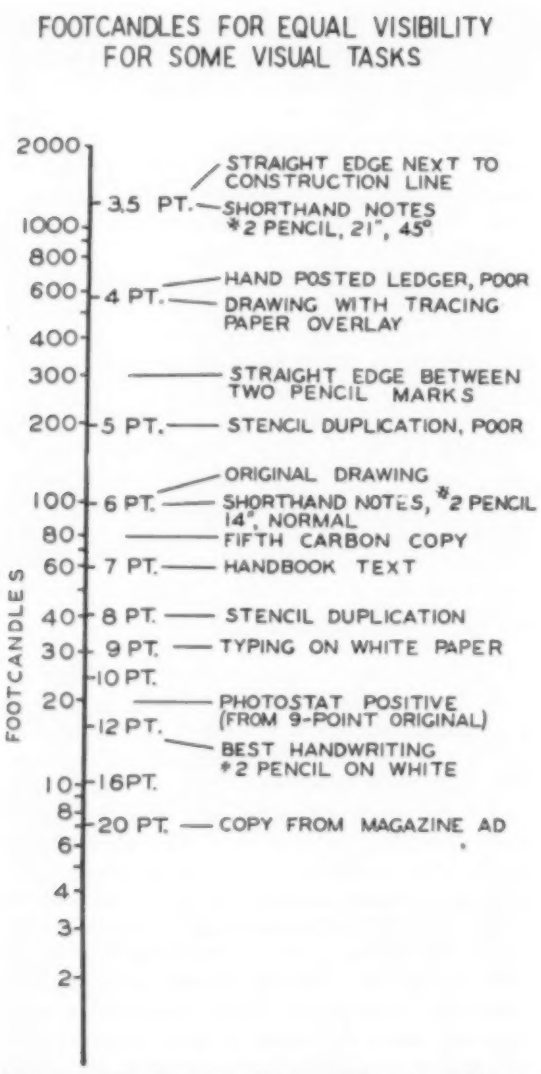


Figure 8. The basis for this comparison (an arbitrary one) is the visibility of typical typing on white paper at 30 footcandles.

Bodoni type) as viewed at 30 footcandles, the recommended illumination value for the ordinary seeing tasks of offices. This gives an indication of the effectiveness of illumination as a magnifier in improving the effective size of difficult visual tasks. Any other reference condition that may be desired can be established. Under other conditions, the illumination values shown for the various tasks would be shifted, although the relative footcandles between any two tasks would be about the same.

Conclusions

The variation in the visibility of office tasks is considerable. Some control over the visual task contrast is possible in offices where care is taken to provide the papers, typewriter ribbons, carbon sheets and writing instruments which can supply best visibility, and where skill is employed in duplicating processes. In addition, some control can be exercised over task size by positioning material that is read at an appropriate distance and angle in order to get the benefit of full visual size, and by designing office forms with adequate space for writing, for example.

As helpful as the above practices may be in providing improvements in visibility of some measureable degree, the inherent visibility of many tasks is of such a low order that light, properly applied, must be the solution to better seeing. General illumination supplied with a high order of visual comfort, without reflected glare (usually), and of an amount fitted to the character of the task, is one primary method of improving visibility. The use of supplementary lighting devices which control distribution and brightness for a particular application, is another. There are many opportunities for equipment manufacturers to provide new designs which fit specific needs. Among these might be a luminous typewriter platen for proofreading stencils in the machine, lighting for the typewriter margin scale and key guide, illuminated dials for calculating machines, luminous panels with controllable brightness, and lighting for the several kinds of raised copy holders.

Acknowledgments

The authors wish to thank the many people who have helped with this study. We would like particularly to thank Mr. A. A. Eastman who was generous with his time for consultation during the laboratory testing and Miss Doris Dambrow who prepared all the typing samples and participated in some of the tests. Nearly six hundred samples involving about nine thousand individual visibility readings were made in the laboratory.

Equivalent Type Size for Some Office And Drafting Visual Tasks

TASK CATEGORY	EQUIVALENT BODONI TYPE SIZE (Points)
1. BOOKKEEPING	
Calculating Machines (3)	
Dials, Black Numbers on White	8.0
Red Numbers on White	7.0
White Numbers on Black	6.0
Yellow Numbers on Black	4.0
Keys, Black Number on Beige Key	13.5
Cream Number on Green Key	9.0
Tapes, Black Totals	8.5
Red Totals	6.5
Ledgers	
Hand Posted, Black Ink, Typical	7.0
Hand Posted, Black Ink, Poor	4.0
Machine Posted, Black Ribbon	8.5

TASK CATEGORY	EQUIVALENT BODONI TYPE SIZE (Points)
2. DRAFTING	
Drawings	
Original, Pencil on Paper Viewed Against 60% Reflectance Background	6.0
Black and White Reproduction	6.5
Blueprint	6.0
With Tracing Paper Overlay, 51% Trans., 41% Refl.	
Original, 60% Reflectance Background	4.0
Black and White Reproduction	4.0
Blueprint	4.0
With Tracing Paper Overlay, 100 Footlambert Luminous Background	
Original	14.5
Black and White Reproduction	11.0
Blueprint	9.0
With Tracing Paper Overlay, 200 Footlambert Luminous Background	
Original	21+
Black and White Reproduction	15.0
Blueprint	13.5
With Tracing Paper Overlay, 300 Footlambert Luminous Background	
Original	21+
Black and White Reproduction	18.0
Blueprint	18.0
Field Markings on Blueprints	
Handwritten with Black Ink	Less Than 3.0
Handwritten with Pencil	
#1 Black Lead	3.5
Red	3.5
White	6.5
Yellow	6.0
Instruments	
Protractor, 6" Clear Plastic, ½ Degree	5.5
Scales	
Architect's Triangular Boxwood, ¼"	4.5
Architect's Triangular White Plastic, ¼"	6.0
Drafting Machine, Brushed Aluminum, ⅛"	9.0
Flat, White Plastic, ⅛"	6.0
Slide Rule, 10", lines between 2 and 3	5.5
Specific Visual Tasks	
Dot made by heavy pencil pressure	6.0
Lines, Drawn with 4H Pencil, Pressure Varied	
Heavy Pressure	11.0
Moderately Heavy Pressure	8.0
Moderately Light Pressure	5.0
Light Pressure	3.0
Protractor, Clear Plastic, Viewed Against Black Line at Edge of Scale	5.0
Straight Edge, Clear Plastic, Viewed:	
Parallel to Light Construction Line	3.0
Parallel to Moderately Light Construction Line	3.5
Between Two Heavy Pencil Marks	4.5
8. DUPLICATED MATERIAL	
Black and White Reproductions (All Elite Type)	
9# White Onionskin Original, Plain	7.5
Reproduction of Above	7.5
9# White Onionskin Original, Prepared with Orange Carbon Backing	10.0
Reproduction of Above	12.0
9# Yellow Paper Original, Plain	8.0
Reproduction of Above	8.0
9# Yellow Paper Original, with Orange Carbon Backing	8.5
Reproduction of Above	9.5
Heat-Sensitive Paper Duplicator	
Original	9.0
Reproduction	8.5
Hectographing, Liquid, Typical (Elite Type)	8.0
Offset Printing, Typical (Elite Type)	9.0
Photo-Sensitive Paper Duplicator	
Original	9.0
First Copy from Master	9.0
Seventh Copy from Master	4.5
Photostats	
Original	9.0
Positive	11.5
Negative	8.5
Stencil Duplication, Typical (Elite Type)	8.0
Stencil Duplication, Poor (Elite Type)	5.0

TASK CATEGORY	EQUIVALENT BODONI TYPE SIZE (Points)
4. DUPLICATING STENCILS AND MASTERS	
Address Masters	
Metal Plates, Zinc	5.0
Metal Plates, Brass	9.0
Paper Plates, Before Inking	4.5
Paper Plates, Inked	3.5
Duplicating Stencils* (Elite Type)	
Blue, Clear Plastic Cushion Sheet	4.0
Blue, Yellow Wax Cushion Sheet	5.0
Yellow, Clear Plastic Cushion Sheet	3.5
Yellow, Black Cushion Sheet	6.5
Orange, Clear Plastic Cushion Sheet	3.5
Orange, Black Cushion Sheet	5.5
Green, Black Cushion Sheet	4.5
Hectograph Masters (Elite Type)	8.0
Offset Process Masters (Elite Type)	8.0
5. HANDWRITING	
On Reference White Paper of Typing Test	
Pencils	
#1	8.5
#2 (Average of 11 Persons)	8.0
#2½	7.0
#3	6.0
Blue	7.0
Green	5.5
Red	6.0
Range of 11 Persons' Writing with #2 Pencils	3.5 to 13.0
Pens	
Ballpoint	
Black	8.0
Blue	7.5
Green	6.5
Red	6.0
Fountain, Black Ink	
Broad Point	10.0
Medium Point	9.5
Fine Point	9.0
Bookkeeping (Very Fine)	7.5
Fountain, Medium Point, Colored Ink	
Blue	7.5
Brown	7.5
Green	7.5
Red	6.0
On White Ruled Pad Paper	
Blue Ballpoint Pen	
Written with Pad Backing	8.5
Written with Hard Surface Backing	7.5
On Yellow Legal Pad Paper	
Blue Ballpoint Pen	
Written with Pad Backing	9.0
Written with Hard Surface Backing	8.0
Miscellaneous Handwriting Samples on Printed Forms (Not Directly Comparable with Other Handwriting Reported in this Category)	
Bank Deposit Slip — Black Ink on White Form	6.0
Bank Money Order Requisition — Black Ink on Green Form	5.5
Bank Money Order Requisition — Blue Ballpoint Pen on Blue Form	4.5
Postal Money Order Requisition — Blue Ballpoint Pen on White Form	5.0
Postal Money Order — Blue Ink on Gray Printed Form	6.0
6. MAIL COVERS	
Addressing Machine on Brown	6.5
Addressing Machine on White	9.0
Handwritten in Ink on White	10.0
Typed on White Envelopes	8.5
Range Observed — All Conditions	5.5 to 12.0
7. PRINTED MATERIAL	
Books	
Dictionaries (4)	
Defined Word, Bold Type	6.5
Definitions, Medium Type	5.5
Handbooks (3)	
Text	7.0
Bibliography	6.0
Graphs	6.0
Table	4.0
Legal (4)	
Typical	7.0
Poor	5.5

*Clear Plastic Overlay, often used in preparing stencils, reduces equivalent type size about one-half point.

TASK CATEGORY	EQUIVALENT BODONI TYPE SIZE (Points)
Medical (4)	
Typical	6.5
Poor	6.0
Reference Textbooks, College Level (4)	7.5
Corporation Stock (1), Fine Print	3.5
Galley Proofs	
10 Pt. Baskerville on Coated (Semi-Gloss) White, Typical	8.0
10 Pt. Baskerville, on Coated White Poorly Inked	6.5
8 Pt. Sans Serif Medium, On Mat White, Typical	7.5
8 Pt. Sans Serif Medium, White on Black, Typical	7.5
Insurance Policies (2)	6.0
Magazines (9)	
Advertising	
From Same Ad (Max.)	21.0
(Min.)	6.0
Charts	
Typical	6.0
Poor	3.5
Graphs	
Typical	6.0
Poor	4.5
Reference Symbols for Footnotes	5.5
Text	7.0
U. S. Patents (Text)	7.5
U. S. Savings Bond (Time and Interest Table)	4.5
8. SHORTHAND NOTES	
On Stenographic Note Paper	
#2 Pencil	6.0
#3 Pencil	5.0
Bookkeeping Pen (Blue Ink)	5.0
9. TYPING	
Typed Originals — Elite Type	
Reference White Paper (81% Reflectance)	
New Black Ribbon	12.0
Typical Used Black Ribbon	9.0
Worn Black Ribbon	4.0
New Blue Ribbon	10.5
New Brown Ribbon	10.0
New Red Ribbon	8.0
Colored Paper, New Black Ribbon	
Blue (56% Reflectance)	9.0
Cherry (50% Reflectance)	8.5
Goldenrod (56% Reflectance)	9.0
Pink (57% Reflectance)	9.0
Russet (50% Reflectance)	7.5
Salmon (54% Reflectance)	9.0
Yellow (70% Reflectance)	10.0
Typed Carbon Copies on 9# White Onionskin with Reference Carbon Paper	
First Copy (2 Carbons Made)	9.0
First Copy (6 Carbons Made)	8.0
Fifth Copy (6 Carbons Made)	6.5

References

1. Luckiesh, Matthew, Eastman, A. A., and Guth, S. K.: "Technique of Using the Luckiesh-Moss Visibility Meter," ILLUMINATING ENGINEERING, Vol. XLIII, No. 3 (March 1948).
2. Luckiesh, Matthew, and Moss, Frank K.: *Reading as a Visual Task*, D. Van Nostrand Co., New York, 1942.
3. Ketch, J. M., and Allen, C. J.: "Visibility of School Tasks," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 6 (June 1953).
4. Luckiesh, Matthew: *Light, Vision, and Seeing*, D. Van Nostrand Co., New York, 1944.

DISCUSSION

C. J. ALLEN:* The authors are to be complimented on their fine and comprehensive study of office tasks. Certainly, lighting recommendations should stem from a thorough knowledge of the visibility characteristics of the tasks to be performed.

It seems significant that type sizes smaller than 8-point are seldom used in book printing, yet many of the common office tasks reported upon in the paper are significantly below that visibility level. We generally think of reading as a difficult seeing task, yet most typical office tasks are significantly more difficult. I believe this partially explains why so many management groups, who understand the human needs and benefits of good lighting are specifying the higher illumination levels. I recently was privileged to visit a large installation consisting of tens of thousands of square feet of engineering design space where the needle of my 200-footcandle light meter was consistently off the scale in all work areas.

This paper well points out the need for higher footcandle levels to which we are rapidly progressing. In most cases, this will be accomplished by general lighting but we must not overlook the potentials of supplementary lighting for producing the needed increases in visibility which are desirable for many tasks. Such supplementary lighting must adhere to good lighting practices. It must not present any high brightnesses to the user. The lighting results must blend in brightness ratio-wise with the task surroundings. And, of course, reflected glare must be kept at a minimum. Along this line, I would like to ask the authors if a controllable brightness transilluminated table would not make a good drafting surface for general use in making original drawings. Transilluminated panels in the past have generally been though of only in connection with tracing work. In this respect, I visualize a transilluminated panel drawing board with a maximum brightness of about 300 footlamberts and used in a room which provides 50 to 100 footcandles of general lighting. It seems that such an arrangement would practically eliminate the T-square shadow problem. It gives a draftsman a good opportunity to see how black and white or blueprints will be reproduced. And, of course, these two benefits would be an addition to the control he has over the visibility of his drawing.

JOHN J. NEIDHART:* This paper contains a wealth of information, and I hope that its potential value will be fully realized by its extensive use. I liked the equivalent type size concept when it was first presented for school tasks by Ketch and Allen, and I am glad to see it extended to office tasks. Equivalent type size is such a graphic and easily understood means of presenting relative visibility that it can and should be used to convince office managers that they should take steps to improve the visibility of many unnecessarily difficult office seeing tasks. The excessive reuse of carbon paper and the use of low reflectance papers are examples of undesirable practices that could easily be corrected. It is true that we can design lighting installations that will provide satisfactory visibility of these unnecessarily difficult tasks, but this will not always be practical or feasible. It is the responsibility of the lighting engineer to do all he can to provide good seeing conditions in the area he is lighting, and recommendations for improving visibility of the task are a part of his job.

There are, of course, many difficult visual tasks which can be made more visible only by providing relatively high illumination levels. Fig. 8 seems to indicate a need for exceptionally high illumination levels on some tasks, but it must be emphasized — as the authors did — that these are based upon an arbitrary reference base. It should also be noted that neither these levels nor the arbitrary reference base recognize the frequency of occurrence of the task or how prolonged it might be nor do they recognize practical considerations. Research studies are now underway to determine performance levels that can be achieved with different illumination levels on basic visual tasks. When these studies are completed, we should be able to establish recommended illumination levels to achieve whatever performance level is considered to be desirable from a practical standpoint. Until we have this information, however, we have

*General Electric Co., Nela Park, Cleveland, Ohio.

*Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio.

no basis for increasing our recommended illumination levels. We have, therefore, made very little change in recommended levels in the new Recommended Practice for Office Lighting but have indicated that under proper environmental conditions, higher levels are desirable when practicable. We have also pointed out that the recommended illumination should be provided on the work surface and that many office tasks are on vertical or near vertical surfaces. Office tasks that may be on other than horizontal surfaces are flagged in the table, and it is recommended that the horizontal level be increased on the basis of vertical illumination being only ⅓ to ½ of the horizontal illumination. If this practice is followed, stenographers would be able to tilt their transcribed notes to achieve maximum effective type size as described by the authors without reducing the illumination below the recommended 50 footcandles.

WILLIAM DALRYMPLE:* The authors should certainly be commended on the exacting work they have done in the preparation of this paper, and it should certainly be of great assistance for the more positive layout of a proper office lighting system.

There is one part, however, on which it is felt considerably more work could be done and that is the percentage of time on the various visual tasks which should be the controlling factor in the overall footcandle intensity required in an office area. It is quite obvious that if a much higher level is needed to read the fifth carbon copy of a letter that the overall office should not be brought up to this level if this condition is only going to happen once or twice a day.

It is felt, therefore, that further study as to the proportion of time for the various tasks and the control which that proportionate time should have on the overall lighting level would add a great deal to the possibility of a better economical job being accomplished.

GEORGE J. TAYLOR:** The authors have provided a paper that will appeal to office management. It is written in a practical vein and is easy to understand. The suggestion that very light tints be used where color coding is necessary is indeed a good one as being important for increased visibility. Better yet, as the authors state, is the use of color identification only on the top corner of the page allowing for maximum visibility with white paper. Aside from "habit," it is difficult to understand why we have not come to this long ago, since it is better for employees, not to mention improved efficiency and productivity.

Testing of typed paper was performed with a "light" opaque background. It should not be assumed that persons reading either original letters or carbon copies would normally back them up with a light surface. By doing this it naturally would increase the apparent reflectance and improve visibility. However, you can not count on people doing this and it is likely that most of them do not follow this practice. This would emphasize the importance of using "white" paper for carbon copies. Imagine how difficult it would be to read the typing on the last (5) sample of Fig. 2 if the carbon paper was a solid pink.

It is interesting to note that carbon paper loses its usefulness after being used 12 to 15 times. I wonder what the carbon paper manufacturers think. Without voicing commercialism they probably would vote for 12 times and in so doing, ease the seeing of office workers. If it is conservatively estimated that it costs about one dollar to prepare a letter, it would seem economical to use the telephone more often. This is particularly true where an answer is required and especially if the answer needs further attention by correspondence.

Fig. 8 is an excellent presentation of common facts. If 30 footcandles are required for typing on white paper then it takes 80 to read, with the same degree of ease, a fifth carbon copy and 100 for shorthand notes when using a #2 pencil with viewing at 14 inches. Remember though, that this all applies to normal eyes. Slight defects in vision might double these values and more serious eye trouble could call for quadruple the values cited. Moreover, the 30 footcandles to which the authors refer as the recommended illumination values for ordinary seeing tasks in offices is to be considered as a minimum. Higher values in today's office activities are generally desirable.

The table of equivalent type size for some office and drafting visual tasks is most useful, especially with Fig. 8 at hand. This paper should somehow reach the desks of all office managers in the country.

W. S. FISHER and H. M. SCHMIES:* The consistently low visibility of the typical drafting tasks observed during this study makes Mr. Allen's suggestion of using transilluminated tables for preparing original drawings look very good. This would be an efficient way of moving visibility levels into the middle or upper ranges even though present-day practice or philosophy seems to limit the use of general lighting levels to 150 or 200 footcandles. (There are some examples of even higher levels in use.) This would not lessen the need for high levels of general lighting. Indeed, it might call for even more illumination in some areas which are presently considered up to standard, to preserve good balance among brightnesses in the visual field. Of course, general lighting adds importantly to the visibility.

One of Mr. Neidhart's statements touches on a significant point. The lighting engineer, if he is really to engineer the whole job for his clients and customers, has a responsibility exceeding that of providing mere footcandles. To do a comprehensive job — one that will provide an economic and practicable solution to a lighting problem — requires knowledge of the task, as well as of light sources and equipment. The knowledge of many of us on this is meager.

Mr. Dalrymple indicates that we need more information regarding tasks such as time involved in working at seeing jobs of different visibility levels. This might lead us to a weighted average task visibility. Such information would be useful though, having such a figure, finding "average" offices or people to apply it to might be difficult.

Mr. Taylor points out that the data reported on are for people with "normal" eyes and that quantity of illumination requirements would soar if we were to attempt to provide the same visibility of tasks to sub-normal eyes. As true as this statement is, Eastman and Guth's paper[1] indicates that visibility varies considerably even among people with so-called "normal" eyesight.

When all things are considered, increased levels of illumination become the key to making things easier to see by overcoming poor task characteristics, sub-normal vision, and differences between individuals. Perhaps future researches will enable us to identify worker performance and ease of seeing more closely with quantity of illumination. However, indications are that optimum illumination levels for many office and drafting tasks are well above the recommended values of today's practices.

1. Eastman, A. A. and Guth, S. K.: "Footcandles for the Forgotten Man," ILLUMINATING ENGINEERING, Vol. L, No. 3 (March 1956).

*Amalgamated Electric Corp., Ltd., Toronto, Ont.
**Day-Brite Lighting Inc., New York, N. Y.

*Authors.

Before

Relighting and Refinishing for

DESIGN OBJECTIVES were: high-level good quality, controlled lighting with brightness balance, at a reasonable cost. The installation is in an executive office in the Public Service Building, Portland, Ore.

For a private office this area is rather large (28 feet 4 inches by 22 feet), with the work space of table, desk and chairs covering approximately one-half the room. The "before" photo shows the massive mahogany desk and table, with dark and highly polished surfaces. The walnut doors, wainscot and window trim, which covered almost half the wall area, were also very dark. The lighting was provided by two 1500-watt indirect incandescent luminaires and four 50-watt ornamental wall brackets for decorative purposes. These provided an average level of 15 footcandles.

Because of the large room size it was felt that the proportions of the room should be retained. This and a decision on a luminous ceiling system necessitated the removal of the false beam ceiling to obtain plenum space. A massive structural member in the center of the room dictated the division of the ceiling area into two equal panels with a center strip of tile to hide this unsightly beam. The use of acoustical tile over this beam and around the edges of the room added to the appearance of the room as well as to its acoustical characteristics.

With the false beam ceiling removed, ceiling height of the room was 12 feet. The vinyl plastic panels in 2 x 2-foot sections were installed flush with the covered center beam 1½ feet below the ceiling. A total of 72 rapid-start strip-light units are mounted in nine rows per panel on 12-inch centers in the plenum. All plenum surfaces are painted with high-reflectance gloss white.

Low-voltage controls, located on the desk, permit the choice of 33, 66 or 100 footcandles illumination.

Brightness balance has been obtained by repainting all wall surfaces, by bleaching the dark woodwork and furniture to increase reflectances and improve brightness ratios. New carpeting has replaced the original dark carpet.

AUTHOR: Commercial Sales Manager, Pacific Power & Light Co., Portland, Ore. This installation, in his company's building, won for Mr. Reis the first prize in the IES Oregon Section's 1955 contest for My Most Interesting Lighting Job.

After

a Controlled Visual Environment

By FRANK M. REIS

Room Statistics

• Reflection Factors	Before	After
Walls	61%	73%
Wainscot	12%	30%
Carpeted Floor	12%	28%
Table and Desk	10%	27%
Chairs	2%	21%

• Brightness Ratios
- Maximum in room—14.5 to 1, between plastic and wainscot.
- Maximum in normal field of vision—8.7 to 1, between task and wainscot.
- Foveal field—3 to 1, between task and table.

• Illumination Levels
- Before—15 ft-c
- After—33, 66 or 100 ft-c

• Brightnesses at 100 ft-c*

Plastic Ceiling	160 ft-L
Task	96 ft-L
Walls	35 ft-L
Table	32 ft-L
Chairs	25 ft-L
Floor	23 ft-L
Tile Ceiling	17 ft-L
Wainscot	11 ft-L

• Load
- Before—3 kw, with two 1500-watt indirect incandescent fixtures
- After—3.6 kw, with 72 48-inch T12 rapid start strip fixtures

• Watts per square foot
- 100 ft-c — 5.8
- 66 ft-c — 3.9
- 33 ft-c — 2.0

• Cost

Demolition of False Ceiling	$ 175
72 strips installed and low voltage control	1,001
Plastic tile and hangers — installed	1,268
Painting and Bleaching	720

• Cost per square foot — $5.10

*All brightness values are an average of three readings by the author using a Luckiesh-Taylor brightness meter.

Engineered Home Lighting Using Prismatic Lenses and Refractors

By CLARENCE C. KELLER

Some of the technical progress of the last sixty years has reached the home level. Engineered central heating systems have replaced the traditional fireplaces; and engineered kitchens, bathrooms and laundries are now commonplace. Engineered *lighting* can be found everywhere *but* in the home. We can make homes as safe, convenient and comfortable by night as by day; as safe, convenient and comfortable every day as they are occasionally by natural light alone on good days. This includes those critical areas outside the home such as steps, entrances, walkways and driveways that are so important for safety, convenience, comfort and protection against intruders.

The problems of visibility, efficiency and comfort can be succesfully solved in the modern home by applying the lighting principles and practices which have been developed in the fields of office, school, industrial and street lighting. This concept involves the separate consideration of the functional lighting, which is a matter of engineering and planning, and the environmental lighting, which is a matter of taste and is determined largely by the occupant of the house. The latter is most simply met by the judicious use of portable lamps and decorative fixtures; the former, by planning the lighting at the same time the other mechanical services are decided upon.

Any proper consideration of this subject requires a word on safety. The basic purpose of a home is self-preservation. People actually cannot stay alive without shelter. It is strange to find in this country that these havens of physical, aesthetic and spiritual safety are highly dangerous places. The National Safety Council reported that in 1953 there occurred in homes 4,350,000 accidents severe enough to need treatment, and 29,000 accidental deaths. These alarming figures are even more significant when it is realized this is an increase from 2,000,000 such accidents in 1949.

A glance at the diagram in Fig. 1 will show that 21 per cent of the victims met their unfortunate fate on the porches and outside stairs. These are the most poorly lighted places about the home. More than half of the home accidents, 51.7 per cent, take place at these locations, and in the yard, garden or driveway, and the inside hall. These are the most dimly lighted locations at night, when 60 per cent of the accidents occur. The major danger spots, porches and outside steps, yard or ground, kitchen and halls, account for 70 per cent of the accidents. Outside steps, porches and grounds, which account for 42 per cent of the accidents, are often not lighted at all after the sun goes down. Along with the kitchens, halls and stairs, etc., these are ideal places for engineered lighting.

Another significant fact is that 30 per cent of all accidents occur to the hands and fingers. This suggests reliance on the sense of touch in the absence of sufficient light.

The most important tool of the illuminating engineer in planning any lighting installation is the photometric distribution curve. It is the chief source of data available to him in the prediction of

Figure 1. Where accidents occur in the home. Giving emphasis to the fact that the majority of accidents occur at locations that are usually poorly lighted, and that would benefit most from the application of engineered distributions and equipment.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHOR: Holophane Company, Inc., New York, N. Y.

Figure 2. Equipment with miniature street lighting distribution applied to underside of overhang on a modern home, to provide adequate and essential protective lighting. Equipment is rugged, dirt and bug-tight and easy to maintain. In the daytime it is inconspicuous.

Figure 4. Equipment with miniature street lighting distribution in a bracket fixture, applied to garage entrance for driveway and grounds lighting.

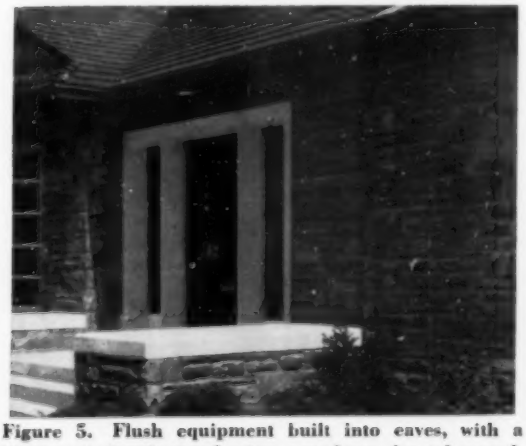


Figure 5. Flush equipment built into eaves, with a downward distribution having a moderate lateral spread. The emphasis here is on lighting the vertical surface of the exterior wall, and brightly lighting visitors at the entrance.

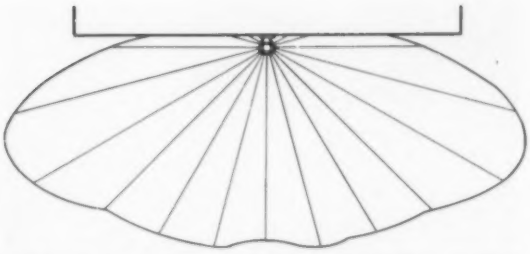


Figure 3. Horizontal and lateral distribution through angle of maximum candlepower for the installation shown in Figs. 2 and 4.

the results to be achieved and the selection and placement of the equipment to produce these results. It was the use of performance data in this manner that was, in a great measure, responsible for the advance in application techniques in the field of commercial, industrial and street lighting.

In the examples shown in Figs. 2 to 23, the reader may find suggestions as to how these engineering considerations may then be applied to his own problem.

The more completely our homes become engineered, the safer, healthier and more comfortable will be the vast majority of people; and statistics, particularly accident and crime, show that we have already waited longer than we should have in introducing, on a large scale, engineered lighting in the home.

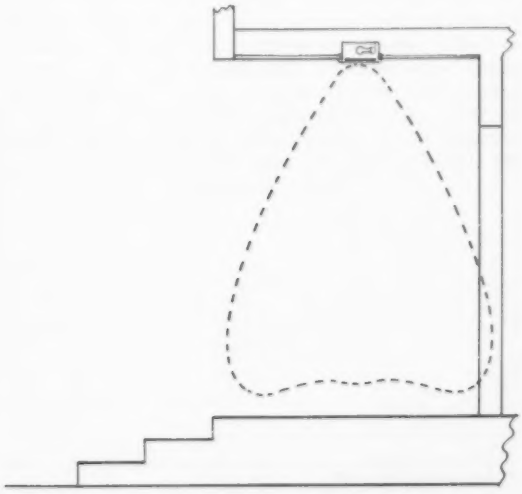
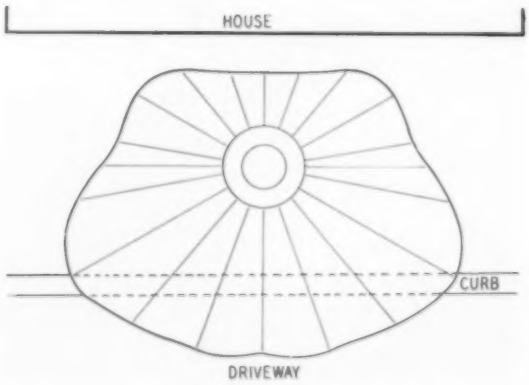


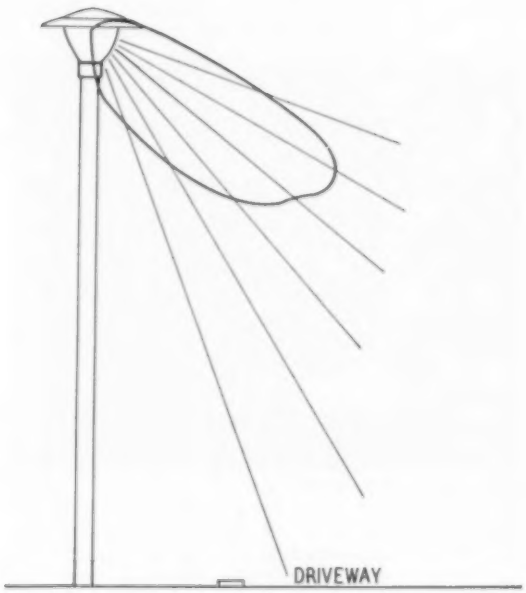
Figure 6. Section showing installation and vertical distribution curve of recessed prismatic lens unit. Note how through location of lighting unit and selection of light distribution the light pattern fits the requirements of lighting the entire doorway and steps.

Figure 7. Approach lighting, for protection and recognition, from a built-in flush wall unit that sends out light in a tilted down, fan-shaped manner. The unit is unnoticeable in the daytime.

Figure 8. Flush equipment built into ceiling of porch with the type of intensive distribution required to deliver 25 footcandles over the porch.

Figure 9. Post-type refractor for grounds lighting, having a typical asymmetric, street lighting distribution aimed at the driveway. The back half of the refractor spreads light at a lower but sufficient intensity around the lawn. The drawing above right shows the fan-shaped horizontal light pattern, while drawing at right shows the vertical distribution indicating how the light is controlled downward.





Acknowledgments

The author gratefully acknowledges the assistance of his associates Messrs. H. L. Logan and M. S. Winslow in obtaining and assembling the material used in this paper.

Figure 10. (Above) Recessed, flush incandescent lens lighting for general lighting, plus localized recessed incandescent lens lighting over sink. The latter has a concentrating distribution to pile the light on the sink operations.

Figure 11. (Right) Section through recessed prismatic lens unit mounted over axis of kitchen sink. Unit provides concentrated distribution across sink with wide spread pattern along sink.

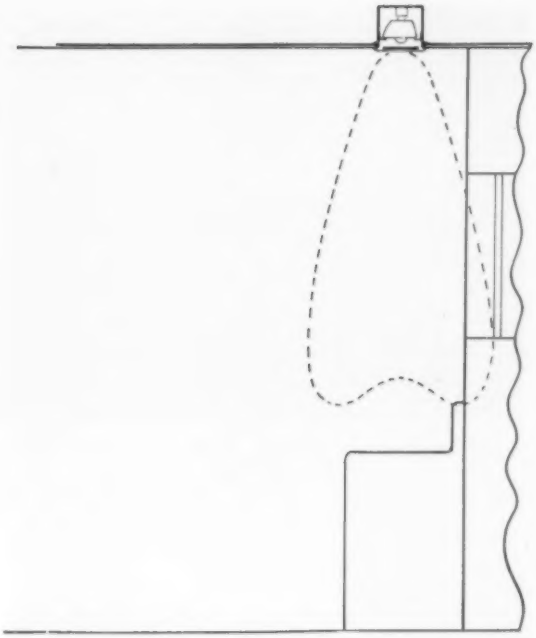


Figure 12. Recessed flush, incandescent lens unit concentrating light on a home laundry operation. Engineered lighting of this sort is ideal for the fixed-location industrial tasks in homes.

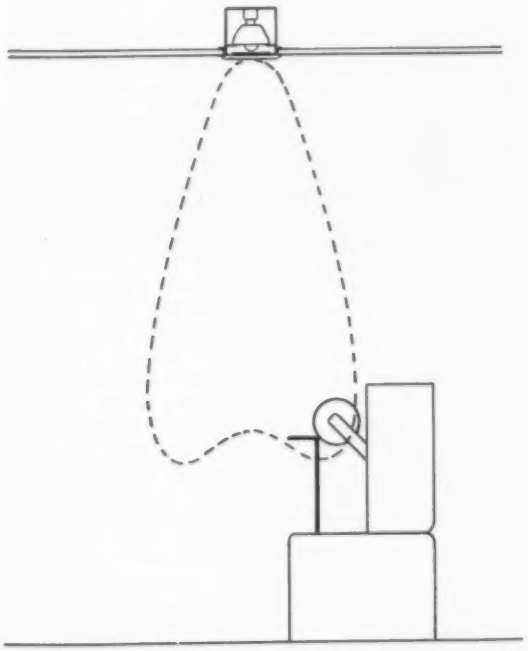


Figure 13. The above sectional view indicates how light is directed so as to utilize the major intensity at the point on the work that must be seen, with adequate general room lighting to provide good visual conditions. Note that the lighting unit is located slightly in front of the ironer so that no shadows are cast by the operator while working.

Figure 14. Combination of recessed, lens-enclosed, low-brightness fluorescent ceiling unit for general illumination, plus localized recessed incandescent lens lighting over the sink and the range.

Figure 13. Highlighting the glass, china, silverware and napery on the dining table from a recessed flush, incandescent lens unit, with general diffuse lighting provided by the corner portable.

Figure 16. Recessed flush, incandescent lens equipment for general lighting. Safety requires a unit, switched from the door, that can light the room. The portable lamps in this instance are properly located to the side of the student providing best visual conditions free from annoying reflections. Unit when located in front of work, *i.e.* with work between eyes and light source, produces either distracting or annoying specular reflection or reduction in ability to see due to dimage from diffuse sources. Convenience also requires a general lighting unit for good housekeeping clean-up purposes.

Figure 17. Den lighting with a double lens unit, incandescent, recessed flush; located over edge of table so no surface reflections come back to the writer, and shadow is under the hand.

Figure 18. (Above) Bedroom with recessed flush, incandescent lens unit for general lighting. The same considerations apply here as in the boys' room. Safety and convenience are best served by a general lighting unit switched from the door.

Figure 19. (Right) Bath-tub lighting. Both safety and cleanliness are best served by individual lighting of the tub. An efficient way is shown — a recessed flush, incandescent lens unit in the ceiling overhead.

Figure 20. Living room with wall lighting from recessed flush, incandescent lens units. Here, where groups gather for relaxation and pleasure, an element of laterally diffused lighting is desirable. This cannot be accomplished directly with overhead equipment, but it can be provided by indirect diffuse reflection from the walls. This light comes at the right angles to soften face shadows and improve personal appearance. Such wall lighting also provides satisfactory emphasis for pictures and other wall decorations.

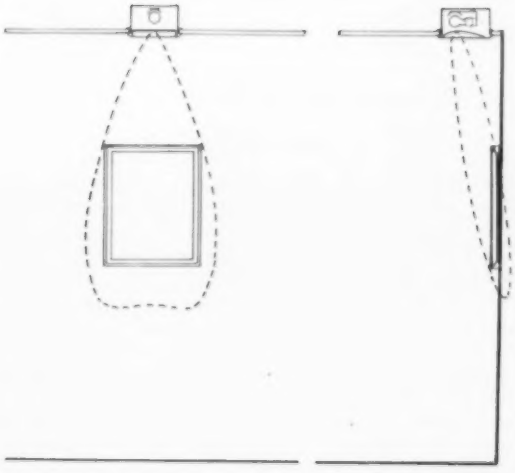


Figure 21. Cross-section and face view through recessed prismatic lens unit showing distribution of light on picture. In order to avoid specular reflections from the pictures, it is necessary to direct the light at an angle of 15 degrees from the vertical and to secure uniform vertical illumination. The angle of maximum candlepower should be directed near the bottom of the area to be lighted. Further, in this installation, the prismatic lens is concave into the ceiling which insures lowest possible brightness toward the eyes of the observer.

Figure 22. Recessed full, three-quarter or half-length mirrors can be well-lighted by installing equipment flush in the overhead soffit as shown.

Figure 23. Hallways in the average home are danger spots, accounting for 12 per cent of all home accidents. They should be free and clear of obstructions, and are not well-suited to the placement of portables. Here the lighting is from recessed flush, incandescent lens equipment.

DISCUSSION

KARL STALEY:* Mr. Keller has again brought into sharp focus some of the points we often overlook in the home lighting field. The translation of his engineering concepts into terms the builder and owner can understand is an interesting and constant challenge to all of us. It is good news indeed that Mr. Keller's company is projecting increasing amounts of engineering talents into home lighting. Up to now, we have had to adapt more or less commercial-looking equipment to such use. I am surprised, however, that the author did not include in his illustrations more adaptations of their concave lens in contemporary homes. Frank Lloyd Wright, Wilbur Riddle and Carl Droppers, architects, all have used it in the Cleveland area. Another point — I am sure that these and other architects will welcome color in home-lighting equipment. Perhaps the new tinted lamps will supply a new harmonic.

*General Electric Co., Nela Park, Cleveland, Ohio.

As a general conclusion, we might well recall that the invention considered by many scientists to be of greatest service to man is still the *lens*. Its application in the home field is charged with great potentials.

CLARENCE C. KELLER:* Thank you, Mr. Staley, for your kind remarks and most constructive suggestions. I, too, regret that no illustrations were available of the comparatively recent development, the concave lens, used in homes. There can be no doubt that, following the basic premise of the paper, the same principles of control and applied engineering that have resulted in comfortable and efficient lighting installations in commercial and institutional interiors can and must be applied to the home.

We hope that in the near future additional data will be available to provide the necessary and desirable supplement to this paper.

*Author.

INSTALLATION AT EAST END FEDERAL SAVINGS AND LOAN ASSOCIATION
5912 PENN AVE., PITTSBURGH, PA.

Lighting a Bank

LIGHTING OBJECTIVE: To provide adequate illumination and a pleasant atmosphere for the employees and customers of the bank.

GENERAL INFORMATION: The relighting of the bank shown above constituted part of the remodeling job on one of the oldest buildings in the shopping district. It is a long and narrow bank measuring approximately 200 feet by 23 feet; ceiling height is 14 feet except at the sides (beyond the coves) where it drops to 12 feet 6 inches. Surface characteristics are as follows:

ceiling (above and below coves), acoustic plaster	light gray	70% RF
walls, plaster		
upper	light green	60% RF
in niche	coral	50% RF
dado, wood	walnut	20% RF
floor, marble	gray	20% RF
columns, marble	black	7% RF
counters, marble		
main, deal plate	black	7% RF
main, front side	red	30% RF
customer, writing desk	black	7% RF
desks		
top, linoleum	light green	40% RF
side, steel	gray	20% RF
chairs, plastic cover	dull green	15% RF
partitions		
railing, wood	walnut	20% RF
low partitions, wood and fluted glass		20% RF

INSTALLATION: Figure 2 shows the location of all lighting equipment. Ninety-four specially designed fluorescent two-lamp troffers (Pittsburgh Plated Products, Pittsburgh, Pennsylvania) are recessed in the ceiling and located in twenty-four parallel rows, (twenty-two rows of four

(over)

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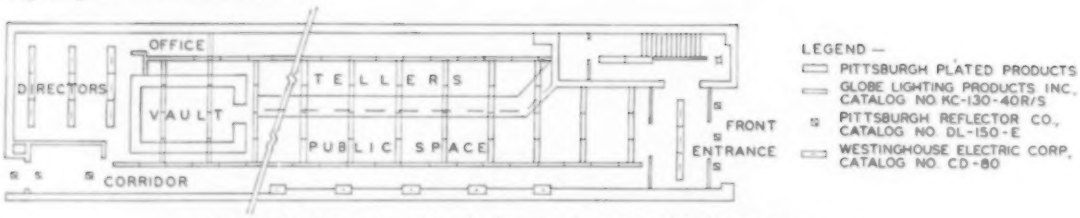

Figure 2. Plan view of bank showing location of lighting equipment.

troffers each and two rows of three troffers each), perpendicular to the coves. The two parallel coves are formed by seventy-nine single lamp "cove-lites" (Globe Lighting Products Inc. catalog No. KG-130-40/RS) equipped with Alba-Lite glass. Twelve luminous indirect two-lamp luminaires with plastic bottoms (Westinghouse Electric Corporation catalog No. CD-80) are suspended 28 inches overall over the directors' section and just inside the front entrance. Forty-watt T-12 standard cool white rapid start fluorescent lamps are used throughout.

Six downlights (Pittsburgh Reflector Company catalog No. DL-150-E), with 150-watt A-23 inside frosted general service lamps and square extensive distribution lenses, are recessed in the ciling at the front entrance and rear of corridor. Five downlights (Solar Light Manufacturing Company catalog No. 130), with 75-watt R-30 floodlamps and concentric ring louvers are recessed in the niches over the customer writing desks.

Illumination measurements are as follows:

general illumination, 3 feet above floor	
front entrance lobby	15 ft-c
public space, average	30 ft-c
counters	
deal plate	35 ft-c
customer, writing desk	55 ft-c
behind counter	
work space	50 ft-c
near wall	26 ft-c
desk	30 ft-c

Brightnesses, under full illumination, are as follows:

fluorescent troffer		walls	
crosswise at 45°	820. ft-L	8 feet up	7.5 ft-L
crosswise at 30°	800. ft-L	5 feet up	12.5 ft-L
lengthwise at 30°	780. ft-L	dado	6. ft-L
cove (at 45°)	470. ft-L	column, 8 feet up	2.4 ft-L
downlights in niche over customer		counters	
writing desk (at 45°)	200. ft-L	main, deal plate	1.6 ft-L
ceiling		main, side	7.2 ft-L
center between troffers	7. ft-L	customer, writing desk	3.7 ft-L
above cove between troffers	200. ft-L	desk	
underneath cove near wall	4. ft-L	top	12. ft-L
floor	17. ft-L	white paper (80% RF) on desk	24. ft-L
		railing (partition)	2.4 ft-L

Lighting designed by George R. Simons, Architect, 6304 Penn Ave., Pittsburgh, Pa., and L. T. Knight, Illuminating Engineer, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.; lighting installed by Yates Electric Co., Butler St., Pittsburgh, Pa.

Lighting data submitted by Armand Zitelli, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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Luminous Interiors for the Home

By E. W. COMMERY

RESIDENTIAL lighting is expanding and moving away from many of the earlier concepts. New approaches to methods and forms of lighting are constantly evolving in this field as well as in the others. This is to be expected as we look at the whole field of residential development. We are witnessing an amazing succession of new construction methods, new materials, new services and a widespread acceptance of scientific and technological advancements in the residential world because they are good.

In the past much of our residential lighting knowledge came from experience gained in some model house or perhaps an individual's home. Seldom are these opportunities found without so many drawbacks and disadvantages that the original objectives either become lost or distorted by unforeseeable and unbelievable conditions. They seldom provide the circumstances for sound technical and artistic study. Seldom are they available for unbroken periods of time to permit the study even though they may possess great merit in themselves.

This paper reports an exploratory study into the field of lighting *for lived-in rooms* rather than service rooms for the home, in which essentially entire walls and ceilings are made luminous either by transmission (self luminous) or by reflection (luminous). An entire room was built for this sole purpose and was operated as a laboratory piece of equipment, although it never gave any evidence of being therapeutic. Considerable study was devoted toward making it a simple but beautiful atmospheric room. The Appendix section of the paper describes the materials, the variables, methods of testing and the constants.

Two basic experiments were conducted in the room with 25 observers using 48 combinations of brightnesses of three principal wall and ceiling areas. Actually there would be no difficulty in creating several hundred combinations.

One area of testing sought to learn the combinations of brightnesses that would receive high acceptance when the lighting is considered for an evening in which relaxing pursuits are the principal objective. This was essentially subjective reaction and esthetic satisfaction; not a matter of production, efficiency or sales, but an intimate personal evaluation. A gratifying correlation developed between the observers and the room as may be seen by referring to Fig. 14 where the spheres show the location of high acceptance. Their fine grouping is encouragement for further subjective testing. Table I sets forth the brightness values which were highly preferred. These, it may be noted, are substantially lower than might be expected. It must be remembered that the intimacy of a small room (15 ft by 17 ft 6 inches by 8 ft 2 inches) may affect the individual to a greater extent than the larger higher ceilinged spaces found in schools, offices and stores. Then too, the intended use of the room, relaxation, also places greater limitations upon the room than would work pursuits.

Can there be lighting conditions that are highly acceptable in this room for both relaxation and casual reading? As the work was completed it was

TABLE I — Combinations of Wall and Ceiling Brightness Rated Excellent for Relaxation. Average acceptance 85 per cent for 25 observers.

Luminous Wall ft-L	Luminous Ceiling ft-L	Bracket Walls ft-L	Floor ft-L	Footcandles at eye
22 on	14 off	20 on	4	4.8
22 "	37 on	11 off	7	5.5
21 "	90 "	16 on	22	10.8
30 "	45 "	16 "	8	7
30 "	85 "	20 "	20	12 *
40 "	25 "	26 "	10	9.5
40 "	80 "	27 "	23	13.0 *
50 "	46 "	16 "	10	9
50 "	45 "	23 "	14	11.7
50 "	80 "	27 "	21	15

*Asterisked lines interpolated. Other values from actual measurement.

Luminous-wall values at approximately 20 ft-L may be used with ceiling values from "off" at 14 ft-L to values up to 90 ft-L. Medium values of wall brackets required.

Luminous-wall values at approximately 30 ft-L may be used with ceiling values from "on" at 20 ft-L to 85 ft-L. Medium to high values of wall brackets required.

Luminous-wall values at approximately 40 ft-L may be used with ceiling values from 25 ft-L to 80 ft-L.

Luminous-wall values at approximately 50 ft-L may be used with ceiling values from 45 ft-L to 80 ft-L. Medium to high wall bracket values included in both the 40 and 50 ft-L luminous wall ranges.

A more generalized limiting statement would be, "With the luminous wall brightness between 20 and 50 ft-L the brightness of the ceiling may go from 40 to 85 ft-L." Medium to high wall-bracket lighting was used throughout this entire area.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHOR: Application Engineering, Lamp Division, General Electric Co., Cleveland, Ohio.

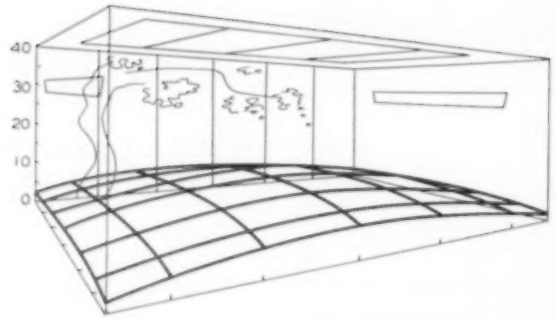

Figure 1. (Left) The plot of illumination from the luminous ceiling suggests an inflated sheet tied to the corners of the room. The 25 measured points are at the line intersections. The test plane itself is horizontal and at 30 inches. The light output is reduced to provide 9 footcandles at the room's center. The lighting at full value for the room averages 43 footcandles. The footcandle is the unit of the vertical scale.

Figure 2. (Right) The even general effect of the luminous ceiling is shown. Fig. 1 represents the corresponding light distribution.

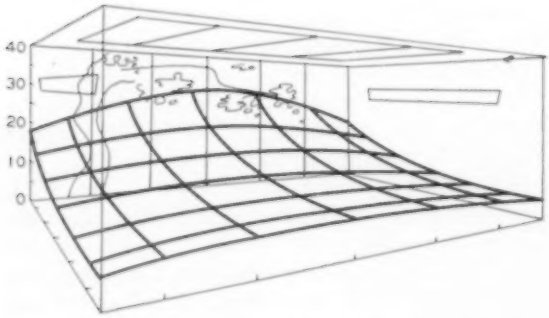

Figure 3. (Left) The distribution of light from the luminous wall measured on the horizontal plane is shaped and hangs like an awning at the wall. The light output is reduced to provide 9 footcandles at the room's center. The average full lighting for the room is 17.5 footcandles.

Figure 4. (Right) The increased openness of the room is suggested when the wall becomes luminous from floor to ceiling. Refer to Fig. 3.

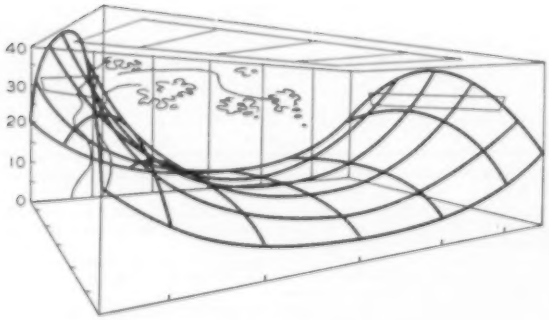

Figure 5. (Left) The saddle shaped lighting distribution is provided by long horizontal wall brackets on the two ends of the room. Normal voltage operation provides 9 footcandles at the room's center. Average horizontal plane illumination 15 footcandles.

Figure 6. (Right) This valuable supplementary lighting effect is plotted in Fig. 5.

TABLE II — Combinations of Wall and Ceiling Brightness Rated Either Unacceptable or Acceptable for Casual Reading.

Luminous Wall ft-L	Luminous Ceiling ft-L	Bracket Walls ft-L	Floor ft-L	Footcandles at Reading Plane	
Not acceptable (25 observers)					
20 on	29 on	4 off	4	3	
24 "	36 "	6 "	6	6	
43 "	37 "	8 "	7	6	
61 "	11 off	7 "	8	6	
22 "	14 "	20 on	4	7	
20 "	16 "	10 "	6	8	
66 "	20 on	10 "	11	8	
115 "	40 "	15 "	18	13	
Acceptance Average 80 per cent (25 observers)					
22 on	37 on	11 on	7	9	*
17 off	89 "	12 off	20	12	
34 on	75 "	24 on	10	14	
29 "	52 "	33 "	11	18	*
20 "	91 "	16 "	22	18	
48 "	45 "	23 "	14	20	*
37 "	82 "	28 "	17	23	*
47 "	82 "	27 "	21	24	*
60 "	163 "	34 "	37	29	
50 "	190 "	38 "	36	37	
63 "	200 "	34 "	38	39	
115 "	185 "	40 "	45	42	
135 "	168 "	50 "	48	44	

*High ratings for both relaxation and casual reading.

found that there is a coincidence area for both attitudes and visual pursuits. It is located between 30 and 50 footlamberts for the self luminous wall and 45 to 85 footlamberts for the luminous ceiling, when used together and when supplemented by medium to full lighting from the wall brackets. The *highest* rating conditions for both pursuits are shown in Table II across the lower three asterisked lines. These acceptances were over 90 per cent.

The second area of testing sought to learn the combination of brightnesses that would be preferred for casual reading, recognizing that the results obtained could not be turned around to establish how much light people would select for reading. The question was never "how much" but rather what condition would you prefer and that, of course, took in everything within the field of view when reading one of our medium-gloss, well-printed weekly magazines. Table II summarizes the prevalence of choices. Here significantly there is a complete rejection of eight of the conditions. Some interest may be attached to the related footcandle values. The rejected points are identified by the white circles around the vertical columns in Fig. 13. Note the close brightness relationships between the reading surface and the floor in many of these conditions.

TABLE III — Brightness Values Created When Each of the Three Sources of Light Is Used Independently. (Values in Footlamberts.)

Source of Light	Floor Center	Curtain Wall	Bracket Wall	Luminous Wall	Ceiling Center	Illumination Reading Plane Fc.
Luminous Ceiling	100	19	14	18	20	12
Luminous Wall	15	85	10	16	11	8
Bracket Wall	3	5 to 10	10	8 to 16	4	15

The luminous ceiling with 15 lamps, is operated at 70 per cent of full value.
The luminous wall with 12 lamps, is operated at full value.
The wall brackets with 6 lamps, are operated at full value.
Multiply by the floor center values by 2 for approximate illumination values.

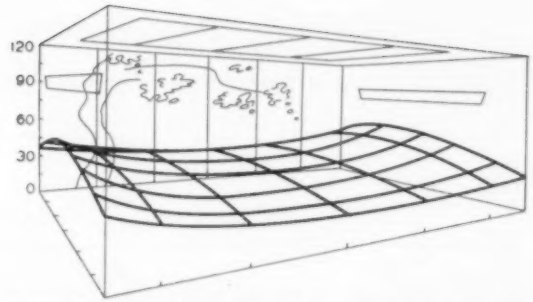

Figure 7. The three separate distributions shown in Figs. 1, 3 and 5 are combined to form this composite. Each was adjusted to the same illumination value (9 footcandles) in the room's center. The lighting now totals 27 footcandles at the center point.

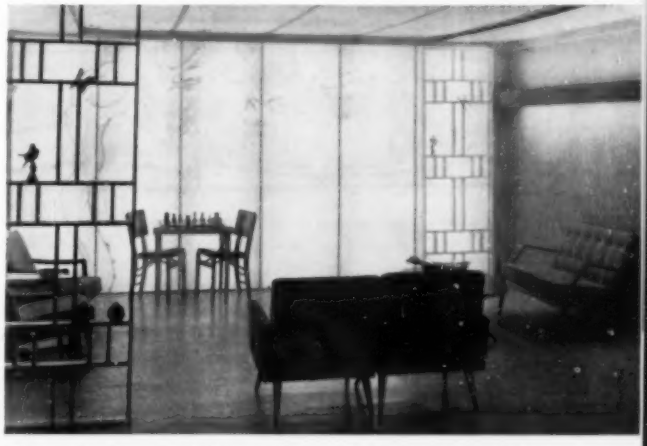

Figure 8. Some of the qualities of the experimental room are indicated when all three of the extended area sources of light are combined. Fig. 7 represents the illumination values measured on a 30-inch high horizontal plane. When all three components are operated together at normal voltage the average illumination for the room is 75 footcandles.

The amounts of light that can be successfully introduced into the design of any room in the home is dependent upon a large number of variables that are entwined in both the decorating and family use objectives. For example, living and family rooms designed to meet the needs of the

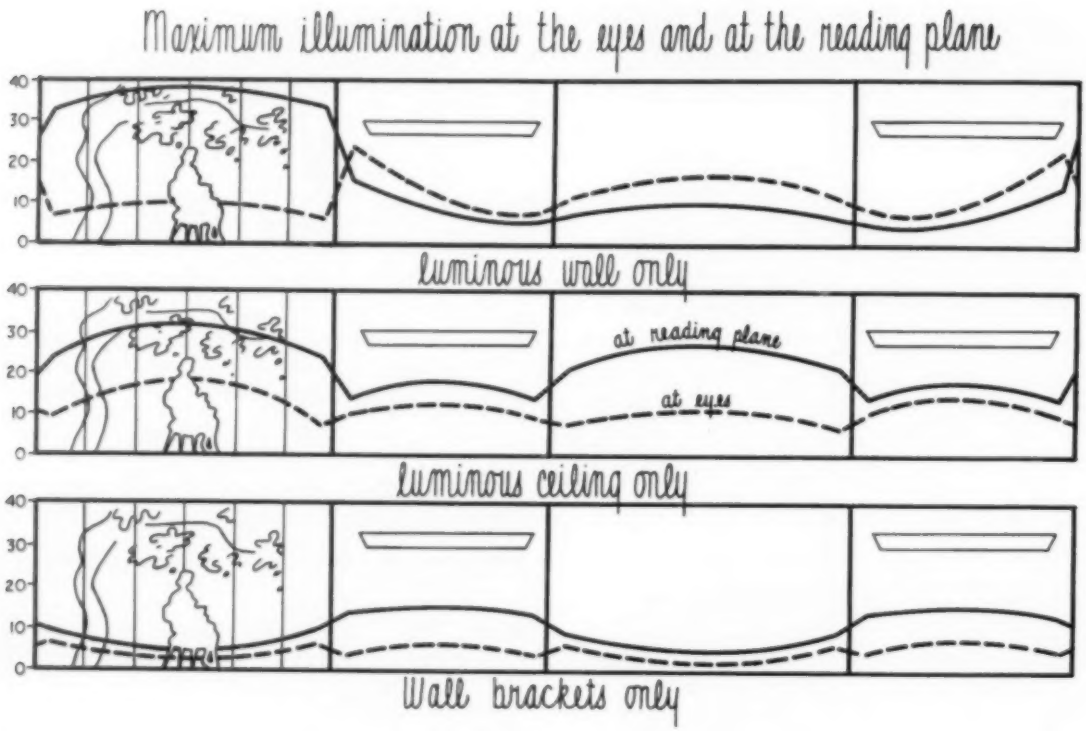

Fig. 9. Each of the three sources of light has its individual quantitative and qualitative characteristics. Footcandle values from each are plotted for reading when seated in a normal position along each of the four walls. A plot of the illumination at the eye from the entire surround when reading is also shown as a broken line throughout.

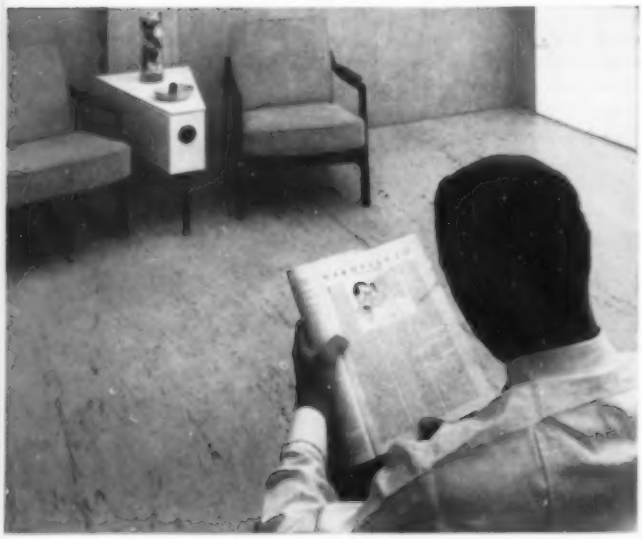

Figure 10. The close ratios of reading plane to background brightness is evident in many of the obtainable lighting combinations. Low specular reflections from the page are demonstrated by the blackness of the type.

family of today must carry a greater burden of service than ever before. Today's new room is an overworked one and that points to the greater ranges of service that the lighting must meet. More than ever this suggests the need for some simple approximate starting point for the lighting design.

We have been experimenting with a system which starts by selecting a single gross figure to establish a value for the lumens that must be generated by the light sources for the room being studied. The size of the room in square feet multiplied by a lumen-per-square-foot value starts the design. After that the designer selects and locates the equipment he wishes to use to meet (a) the seeing needs of the family and (b) to create the desired atmosphere. In principle the procedure is similar to the one used in designing a heating system. The furnace when called upon must be able to deliver a given design value of heat per unit of time or the house cannot be heated to meet a prescribed range of temperature.

The heating designer works from sets of con-

Figure 11. (Left) The atmospheric qualities and eye comfort of the lighting are indicated at this game table.

Figure 12. (Right) No fill lighting of any kind is used to obtain photographs such as this one and the one in Fig. 11. Delightful luminous soft modeling is easily achieved for any evening at home.

stants that have been derived from theory and experiment. One seldom encounters modern heating systems that fail to meet normal living requirements. The lighting designer for the home can look forward to the same procedure. One of the principal steps can be the selection and use of lumens-per-square-foot for the given room and its purposes.

During the last several years we have used a light conditioning standard which when applied to the normal family living room provides 20 to 25 footcandles at each of the family activity centers and an average value of from 5 to 10 footcandles throughout the room. It is closely related to the minimum set forth in the Illuminating Engineering Society's "Recommended Practice for Residence Lighting." After a review of many of these installations, and they have been accepted and admired by thousands of homemakers, we find that they have averaged 70 lumens per square foot. To achieve this acceptance the large areas and surfaces were reasonably light and all of the portable lamp shades and large fixture areas had brightnesses that did not exceed 150 footlamberts.

Now reviewing the data from the measurements made in our luminous-area test room we find that all but one of the most favored choices went above the 70 lumens per square foot design value. Referring to Table II the asterisked lines point to the most successful conditions for both relaxation and reading. The first and second asterisked lines represent the lighting being operated from 50 and 100 generated lumens per square foot respectively. while the last three asterisked lines represent the lighting from 113, 126 and 142 generated lumens per square foot. It is especially significant to note how moderate the brightnesses of the principal areas of the room are at this last value. Obviously the room and the lighting must have supplied a great sense of tranquility and effectiveness to have attained such universal acceptance. All this lends considerable support to the general magnitudes of the lumens per square foot now being discovered for homes; where both relaxation and reading are the criteria.

The graphs, photographs and captions carry additional information that is best told by illustration. Much of it is in addition to the two basic observational experiments since very extensive illumination measurements were made; some of these are indicated in Figs. 1, 3, 5, 7 and 9.

The room possesses fascinating qualities and it is remarkable how wide was its acceptance. Its versatility opens up new vistas in the world of design for the home. Large extended areas of light, when installed under dimmer control, can be used in com-

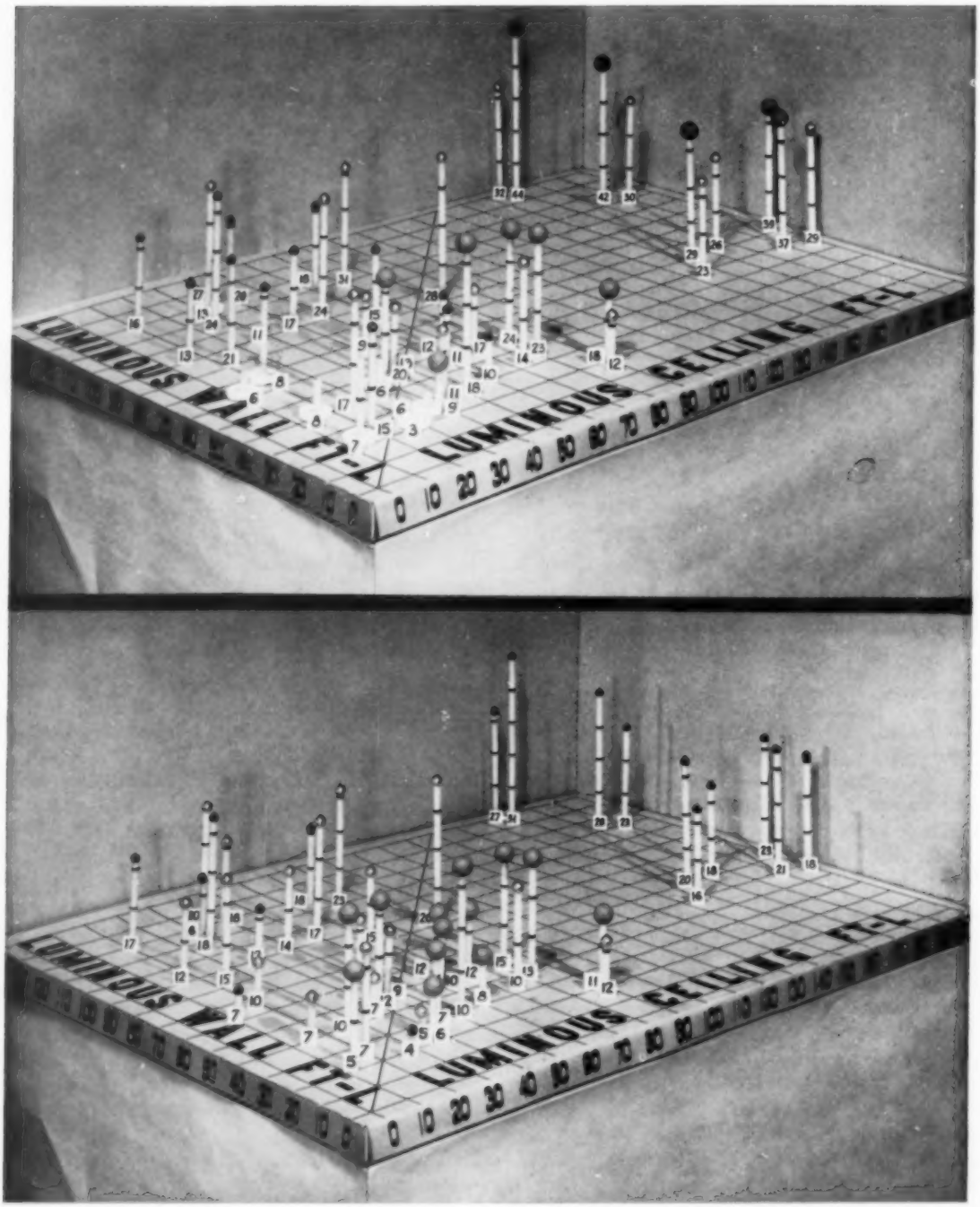

Figure 13. (Top) and Figure 14. (Lower) A model scaled at one inch equals 10 footlamberts for three variables provides the means for arranging and observing quantitative and qualitative studies of the luminous environment. Each of the 48 observation test conditions is located in space — defined by the brightness of the luminous wall and ceiling. The third dimension, the height of each small vertical column, is the average brightness of the wall on which the brackets are placed. The black lines on the columns are 10 footlamberts apart. Three small sphere sizes were used to identify the percentage acceptance of each of the 48 tested conditions. The largest, the medium and the smallest which is also black indicate 60 to 96 per cent, 40 to 60 per cent and 6 to 40 per cent acceptance respectively. The flat white rings represent zero acceptance.

Figure 13. (Top) The acceptances for reading are arranged here. Direct comparison with Fig. 14 (below) indi-

binations to bring about qualities that have scarcely ever been experienced in the field of design. We never need be tied down to the lesser scale of reflecting surfaces. These few beginnings point the way to some of the design problems.

Appendix

The experimental room, 15 ft by 17 ft 6 inches and having an 8 ft 2 inch ceiling, was designed with its floor, walls and ceiling at or near 50 per cent reflectance. The draped sheer yellow wall opposite the luminous wall, could change from 50 to 75 per cent by adding a dark gray to white lining. The latter was selected for these tests.

Considerable study was devoted to the design of the room to obtain openness, visual freedom and an atmosphere that would take one away from the indoors. Including the yellow fabric wall, and it was as free as possible from either reddishness or greenishness, the room was carefully balanced with reasonably high values of both warm and cool colors. The large self luminous areas were essentially white when unlighted and they became the color of the light source when operated; either warm or cool or mixtures of the two. Both deluxe warm white, and cool white fluorescent lamps were used either alone or together.

The two end walls each of which had a 12-foot long row of shielded fluorescent lamps were given special treatment. Here a graduation of brightness and color as well as variations in the natural patterns of the etched, textured plywood panels were employed to bring nature's patterns into the design.

The floor was an off-white vinylite, lightly marbelized in gray with flecks of yellow.

The self luminous ceiling panel of thin corrugated sheet plastic 12 feet square was centered in the ceiling leaving an opaque band on the remaining four sides. This area was painted a light sky blue. Fifteen, 40-watt rapid start fluorescent lamps were arranged in five rows 29 inches apart and 19 inches above the ceiling panel for each circuit. There were two such circuits and sets of lamps separately switched and dimmed. The ceiling brightness could be operated from 5 to 200 footlamberts.

The self luminous wall was composed of diffusing sheet fibreglass panels each 32 inches wide and 8 ft 2 inches high. Six of these were bolted together to form an integrated wall. A single outlined old tree with bursts of cool pink blossoms was lightly sketched with black crayon across these six panels. The blossoms made of colored theater stage gelatine were appliqued on the inside surfaces of the fibreglass. The tree sketch was also on the inner surface of the panel. This association further aided in creating the feeling of being away from an interior. This complete design interferred with the flow of light but little. Other designs may be readily applied to these same panels thereby bringing about a major change of atmosphere and even locale. Such changes may be made without involving substantial costs.

Each of these panels is backed by a 12-inch deep white lined box which in turn contains two rows of 40-watt rapid start fluorescent lamps centered, one directly behind the other. The second row was employed to provide an increased brightness range up to 150 footlamberts from a low of seven footlamberts. Two rows of lamps in a cavity of this size tend to create undesirable shadow and brightness patterns when the rows are used single. Experimentally a satisfactory answer was found.

The versatility of the room is partly suggested by the range of values that were employed in the observational studies in the room. Forty-eight combinations of the three variable sources of light were used. Time permitting, hundreds could be selected for experimental work or for actual living. The three dimensional models in Figs. 13 and 14 show the brightness area in which the room's surfaces may be operated. The potential brightness limits of the room, as the model reveals, are higher than the selected group of observers chose to go. On the other hand we have learned in a limited way that there are individuals who preferred brightness conditions at the upper ends of the possibilities of the room.

The two facing opaque walls at each end of the self luminous wall were made to actively serve in this study by having them provide a substantial amount of light to the room by reflection from six 40-watt rapid start fluorescent lamps placed end to end; three across each wall. Face board shields were placed nine inches out from the wall, seven feet above the floor. These were tipped back from the top and the lamps were centered six inches out from the wall to minimize excessive high light brightness immediately above and below the bracket shield faceboard. This positioning also develops a much better flow of light both up and down the wall. These walls were made of sea swirl plywood painted to aid in developing the concept of the room. A soft gray began at the floor and modulated to a point about 4 ft 6 inches high where it changed up and down with the rhythmic deeply etched wood grain patterns into a soft muted green and continued that way to the ceiling. Over both the gray and green color a warm grayed pink was applied and then rubbed from all the high lights of the wood. The basic colors show through a misty warmth over the entire wall. The grazing light of wall brackets made these natural wood patterns come to life. These walls in their entirety suggest the color and brightness of the woods. The average reflectance of the wall is 40 per cent. The distribution of light from these reflecting walls is particularly favorable for reading when seated at almost any point along the two walls. See Table III for the brightnesses produced in the room by these units used alone. Their importance is also indicated in both Tables I and II as well as in Figs. 5, 6, 8, 9, 13 and 14.

The procedure for obtaining the acceptances or rejections for each of the 48 selected lighting conditions was elementary and simple.

Each of the 25 final observers were in the room alone with the control operator outside. A simple check list having five columns was used by the observer to record the acceptance first for relaxation for an evening and then for casual reading. After a simple explanation by the operator to the observer of what was desired and how the record

cate the shifts that take place between appraisals for relaxation and reading under identical conditions. Also refer to Table II. The small numerals show the illumination at the reading plane for each condition.

Figure 14. (Lower Picture). The acceptances for relaxation in the room indicated here may be further studied by referring to Table I. The small numerals at the bases of the columns show the illumination at the eye when viewing horizontally across the room.

sheet had to be checked "yes" or "no," additional conversation was unnecessary. When the observer could not make a choice he marked both the "yes" and "no" columns. All of the observers were lighting practitioners of mature experience and judgment although they were not exclusively residential lighting specialists.

Every experienced lighting practitioner knows how definite most people can be about deciding whether they like the total effect of an artificially lighted room. We depended upon this ability to judge, to make observations of the room for purposes of relaxation.

The grouping of results for relaxation shown in Fig. 14 was most gratifying. Table I also sets forth an enlightening range of brightness values.

In preliminary runs it became evident that the most important area for investigation was going to begin at 10 footlamberts for the self-luminous wall and ceiling. Upward it appeared that 100 to 150 footlamberts would be the boundary of general acceptance. Thirty-eight of the test conditions are inside these boundaries with the reflecting luminous walls going up to 30 footlamberts. In addition ten more points were selected at higher extremes of both ceiling and wall brightness. The ten points at the rear of Figs. 13 and 14 show these more extreme positions.

The acceptances for casual reading are more scattered as was to be expected since the test condition is not one of critical control. See Fig. 13.

The order in which each of the test conditions is presented to the observer has some bearing on the results. Different orders of presentation could modify. One thing we sought to do was to cross the line which is shown as a diagonal in Figs. 13 and 14. To the right of this line the ceiling, as the viewer sees it, is brighter than the luminous wall. To the left the luminous wall, as viewed, is brighter than the ceiling. This reversing of ceiling to wall brightness ratios aids in exploring the total area of the problem. The observers were led across this line fourteen times during their observational period. Finally the concentration of the high percentage acceptance conditions aids materially in drawing conclusions.

Many places could have been used for locating the observers. The most representative one used is reported. The position is at either of the two ends or right or left hand walls as shown in Figs. 1 and 12. In this position the ceiling, floor and both walls come within view. Directly facing the wall or placing the observer's back to the luminous wall would of necessity call for more complex criteria and time than this first study would permit.

The submitted range of illumination at the observer's reading plane began at three footcandles and went up to 44 footcandles. As previously indicated the self-luminous ceiling could be operated from 10 to 140 footlamberts and the self-luminous wall from 10 to 85 footlamberts. The reflecting source wall could average from one to ten footlamberts. Values higher than these shown in the tables and figures are due to use of combinations of more than one of these sources.

This project was originally instituted with the cooperation of Miss Kaye Leighton and Mr. James H. Jensen. Later as the study developed into a full endeavor C. Messinger and R. Woods developed the room construction and conducted the experimental work. S. M. Mills provided interpretative drawings. Miss Leighton's design on the luminous wall and advice on color and texture gave the room its character. The author gratefully acknowledges his indebtedness to these colleagues.

DISCUSSION

DOMINA EBERLE SPENCER:* Mr. Commery's paper is a milestone in the field of residential lighting. Here a "lived-in room" has been designed, as it should be, for both relaxation and visual tasks. It is indeed a pleasant surprise to find a residential interior which satisfies the most stringent criteria for the luminous environment that have so far been proposed. It satisfies the 3:1 adaptation helios criterion; in fact, it gives even lower ratios.

The 3:1 criterion would allow an overall ratio of 9:1 between the brightest and darkest large areas in the room. But Table I shows that the maximum helios ratio is much less.

$$3.5 \leqq \frac{H_{max}}{H_{min}} \leqq 5.6$$

for relaxation. From Table II similar results are obtained for casual reading:

$$3.4 \leqq \frac{H_{max}}{H_{min}} \leqq 7.5$$

The maximum helios ratios for the five combinations which were given high ratings for both relaxation and casual reading are 5.28, 4.72, 2.43, 4.82 and 3.90. Nearly all the combinations considered acceptable for reading are adjusted so that the ceiling is somewhat brighter than the luminous wall. In only one case is the luminous wall slightly brighter than the luminous ceiling. On the other hand, for relaxation, almost half of the preferred combinations employed a luminous wall that was brighter than the ceiling.

This paper shows that luminous ceilings and luminous walls may be combined to give a wide variety of interesting effects in residential lighting. The 3:1 criterion is satisfied in all cases. A surprising result is that slightly lower helios ratios were chosen for relaxation than for work — a choice which contradicts the prevalent idea that large contrasts are desirable in rooms used for recreation. While the quantities of light preferred are not as high as are being installed in offices, drafting rooms, and schools, they are in some cases about twice as high as those which have previously been employed in similar interiors. If we become accustomed to good lighting in residential interiors, our ideas of suitable quantities of light may be revised upward.

This paper is the starting point for the use of properly engineered quality lighting in homes. It opens a new vista of design and flexibility to architects and interior decorators. It is to be hoped that many of them will experiment with the varied aesthetic effects which can be obtained within the boundaries of quality lighting.

W. F. LITTLE and E. H. SALTER:** The Society is indeed fortunate in having a series of unusual conditions leading up to this paper:

(a) That there is a Mr. E. W. Commery with an exceedingly large fund of knowledge of residence illumination.

(b) That he is willing to place this fund of knowledge at the disposal of the Society.

(c) That he is associated with a company willing to put at his disposal all the equipment and assistance necessary to carry out a survey.

An investigation of residence lighting, taking into consideration the combination of luminous ceilings and walls to the extent shown in this paper, is certainly a novelty well worthy of thorough study. The fact that Mr. Commery has not attempted to reach any definite conclusions is,

*University of Connecticut, Storrs, Conn.
**Electrical Testing Laboratories Inc., New York, N. Y.

in our estimation, merely an admission of the magnitude of the problem.

Having served as guinea pigs, we feel that much knowledge should come from the study. A single series of the 48 observations is not, in our opinion, sufficient to reach anything but the most elementary conclusions. Our feelings after completing the observations were that in the sequence of changing conditions where low brightness might follow high, and vice versa, the evaluations probably were not consistent. A low value seen from a still lower brightness might appear entirely satisfactory, whereas should it follow a high brightness, it would appear to the contrary. This merely means that perhaps the conditions should in each case have a constant value between each change, so that each condition would be approached from a standard condition.

Figs. 13 and 14 show a considerable gap in the brightnesses of the luminous ceiling in the range between 90 and 150 footlamberts. For relaxed conditions there are not satisfactory conditions about 160 footlamberts. It will be interesting to know what would happen in this gap.

We hope that Mr. Commery will carry this test further and present before the Society his additional conclusions. So far the indications would seem to be that wall brightnesses should in the future receive very careful consideration.

L. E. JOHNSON:* This research must certainly be considered to be one of the significant milestones in our search for the brightness patterns which will provide comfortable and satisfying visual environments.

I understand that Mr. Commery has not had a chance to compare the results of this subjective analysis with calculated comfort responses. It would be interesting to see how they do compare.

Perhaps this research indicates that we may someday be able to specify brightness patterns for other moods — for stimulation, buoyancy, coziness, casualness, frivolity, dignity, etc. This is being done now in some cases, but a good deal of trial and error is involved.

A whole new concept of illumination is opened by this type of work. The time is fast approaching, in fact is here now, when we can no longer be satisfied with providing so-called adequate levels of incident light with certain brightness limitations but must consider the entire visual pattern. What this means, of course, is that we must get on with our studies, and research if possible, to learn what this business is all about. We congratulate Mr. Commery for taking a significant step forward in this direction.

E. W. COMMERY:** The three discussors of this paper have been most generous and encouraging. It is gratifying since each in turn has devoted a substantial part of their lives in an area, which would especially qualify them to evaluate this work.

This paper reports on the first of a series of exploratory studies in which light is used as a primary media for the creation of mood, atmosphere, usefulness and perhaps the style of rooms for the home.

Light can be used so negatively that the room will feel neglected, tired and even old. Many of us have noted this all too frequently.

Today we want to know how to design up to the limit. Today we want to know how people react in rooms in which light is integrated into the structure. Today we need to study the total problem in full scale rooms, so that ultimately we will not only be functionally successful, but successful in the eyes of all the related designers whose efforts contribute to a successful home.

We are potentially on the threshold of a new era in lighting design for residential interiors. This contribution is offered to aid in establishing design fundamentals.

Dr. Spencer was especially appreciative of this work. The high acceptance of closely related brightnesses reflects her sincere objectives. Through the careful handling of color, textures and patterns, the room did not appear sterile or monotonous. This has so often been the case, when monotone or closely keyed rooms, having brightness ratios of approximately one to one have been produced.

Mr. Little and Mr. Salter have made helpful suggestions, which are consistent with the exploratory nature of this project. At this time, all we wish to say is that we were able to create a room having remarkable characteristics for a new way of living. Basically we subjected many individuals to the effects of changing values of brightness from all six of the room's surfaces — before we attempted to conduct a regular series of experiments. Satisfactory ratios of ceiling to wall brightness, and vice-versa, were being sought as well as the absolute values of these surfaces. All observers were taken back and forth across the condition of equal wall and ceiling brightness fourteen times. The major effort was devoted to the areas of wall and ceiling brightnesses between 10 and 100 footlamberts. Time was not available for a careful study above the 100-footlambert range. However, ten points representing available extremes, above this 100-footlambert level, were included for the record at this time.

Mr. Johnson proposes a fascinating realm for further subjective testing when he lists the possibility of creating rooms that may be depended upon to provide casualness, frivolity, dignity, etc. It is not unreasonable to assume that these qualities can be intensified in rooms that have already been designed to provide the emotional response which he suggests. We can all strive to know more about the effects that lighting design can be depended upon to produce under all known conditions of design. More studies to determine the constants are in order.

*Northern States Power Co., Minneapolis, Minn.
**Author.

Here and There with I.E.S. Members

CHECK for Sustaining Membership in I.E.S. is presented to President R. F. Hartenstein by J. H. Mead, Vice-President, Southern California Edison Co. (left). At right is Roy Dahlin.

TV interview of Willard Allphin on station CHCH-TV, Hamilton, Ontario, was conducted by Miss Teddy Forman. Mr. Allphin ad-libbed answers to some lighting questions propounded by Miss Forman.

GUEST speaker at the Milwaukee Section's March 22 meeting was Dr. D. A. Frantz, right, optometrist from DeKalb, Ill., who discussed the National Optometric Association booklet, "Home Lighting and Televiewing." The other speaker on the program was I. L. Illing, left, who spoke on quantity and quality of illumination. The ESM emblem stands for Engineers Society of Milwaukee, of which the I.E.S. Section is an affiliate, and in whose building the meeting was held. The meeting was a joint one with the Wisconsin Optometric Association.

TWO events were featured at the New York Section's April 19 meeting. One, shown in photo at left, was the presentation to Miss Caroline Horn of the certificate of Member Emeritus. Section Chairman Lou Goren made the presentation. Also at this meeting, the Section's

MMILJ contest winners were decided. They are: l. to r., in photo at right: Harold Peters, third prize (co-entry with Gerald Gillen); H. L. Sykes, first prize and R. G. Williams, second prize. The meeting was held in the G-E auditorium in New York City.

T E L E C A S T

LIGHTING NEWS OF CURRENT INTEREST

The Fort Worth Story— Regional Conference with a Texas Accent

Regional Conferences are patterned after a written "Guide to the Operation of . . ." But every time, just the same, Texas hosts present a program which is unmistakably different. Vive la différence.

They're abetted by the locale, of course. Coffee breaks in the Texas sunshine on the roof of an elegant hotel isn't something you can include in a Guide for Regional Conferences. All-out local support of every Guide feature, however, contributed a very noticeable feeling of importance and success to the meeting. As will be seen from the statistics, not a single Section or Chapter lacked representation—every local group participated in the pre-conference details — almost everybody had a job, and did it well. In effect, the 72 visitors and 18 non-Regional attendees enjoyed the hospitality of 140 hosts. There were two chairmen, incidentally, and two co-chairmen directing the Papers and Program Committee. From the happy results of this, it could well be a 'difference' worth incorporating into future Guides.

First indication of things to come occurred Sunday evening, April 8, when the Region was host at a cocktail party and President's Reception. The Hilton staff was apparently in the spirit of things too, with a steady stream of fresh Gulf shrimp canapes. This event too was abetted by the surroundings; the Hilton roof patio which circled their famous pool.

On Monday morning the two-fold chairmanship for the Papers program started paying off. John G. Felton, Jr., Southwestern Regional V-P opened the meeting, and J. B. Thomas of the Texas Electric Service Company gave the keynote address. Thereafter, seven sessions, eleven papers of national conference calibre. Details of the papers program are given below; note especially the national character of the lecturers, the particular value of the subjects. Two special luncheons were featured during the conference. I.E.S. President R. F. Hartenstein addressed the luncheon group Monday, reporting on the Society's activities this year. Reverend Hayden Edwards, amusing as well as inspirational, was guest speaker at the luncheon session Tuesday.

M.M.I.L.J.

Miss Ruth Patterson of Dallas Power and Light Company (Southwestern Section) will represent the Region at the national contest in Boston. Her first prize installation was an engineering solution to a church window lighting problem, which of course, also took first prize in the contest conducted last Spring by the Southwestern Section.

Second prize went to Art Vaughn, proxy for the Panhandle Chapter representative. This installation featured the lighting of a bowling alley, the lighting design following exactly I.E.S. layout recommendations.

Third prize was won by Tom Halsey of Alamo Chapter whose interesting job was the illumination of an ornamental screen.

Conference Statistics

Time: April 8-10, 1956

Place: Hilton Hotel
Fort Worth, Texas

Registered Attendance:

Alamo Chapter	7
Ark-La-Tex	19
Central Oklahoma	3
Oil Capital	7
Panhandle	4
San Jacinto	18
Southwestern	64
Non-Regional	18
Total Registration	140
Visitors	72
Total Attendance	212

SOCIAL PROGRAM

Some 24 out-of-town ladies were registered at the Conference, with as many again, and more, local I.E.S. wives joining them in a well-planned social program. They had their own suite in the pent house of the Hilton for a Hospital-

OPENING speaker at an outstanding program, at the Southwestern Regional Conference, was John G. Felton, Jr., Regional V-P. Also shown, left to right, seated, D. V. Hileman, session chairman; L. T. Anderson, co-chairman of the Conference; J. B. Thomas; and President R. F. Hartenstein.

HAPPY recess during Southwestern Regional was a banquet and dance, April 9. President and Mrs. R. F. Hartenstein, center, are here receiving gifts from Region members, presented by John E. Metzenthin, Southwestern Section Chairman.

ity Room. This was busy throughout the conference, for breakfast meetings, coffee breaks, and late afternoon teas. They also had their own luncheon party Monday, at the Greater Fort Worth International Airport, and of course, joined the rest of the conference delegates in the cocktail party, luncheon session on Tuesday, and the Banquet and Dance Monday evening.

Social highlight of the week was the dance, of course. A bit of unscheduled fun during dinner was the mock arrest of President Hartenstein by a *real* Texas sheriff. The charge: a foreigner entering the country without proper credentials. He got out of this with a fine — Texas five-thousand-dollar bills a foot long. The sheriff himself lent quite a bit of color. He was the real thing, but was built on lines straight out of a western movie.

This breach of respect for an I.E.S. President was more than offset by the hospitality of the Region's members who clinched it with gifts to both President and Mrs. Hartenstein. As mementoes of their trip to Texas, Mrs. Hartenstein was presented with a bracelet featuring a map of the state; Mr. Hartenstein, spurs, cufflinks and tie-clip.

Still to Come

Reports on the Regional Conferences held in San Francisco, Seattle, Salt Lake City, Toledo, Indianapolis, Quebec and Washington will appear in subsequent issues of IE.

TECHNICAL PROGRAM

Completely packed sessions attested to the excellence of the papers program. In detail, they were:

Monday, April 9th

Chairman — D. V. Hileman.
Greeting — J. B. Thomas, Texas Electric Service Co.
Seeing Requirements—Basis of Modern Lighting Practice — Sylvester K. Guth, General Electric Co., Cleveland, Ohio.
Lighting Progress Report — James H. McCulloch, Independent Testing Laboratories, Boulder, Colo.

I.E.S. LUNCHEON

Chairman — Edward C. Ober.
Society Report — R. F. Hartenstein, Ohio Edison Co., Akron, Ohio, President, I.E.S.

AFTERNOON SESSION

Chairman — Carlton R. Shepherd.
Comfort Rating Systems — Sylvester K. Guth, General Electric Co., Cleveland, Ohio.
New Office Lighting Recommended Practice—C. L. Crouch, Technical Director, I.E.S., New York, N. Y.

(*Continued on page* 13A)

TWO CHAIRMEN contributed to the success of the Southwestern Regional Conference: L. T. Anderson, left, and H. G. (Casey) Jones.

WINNERS of the MMILJ contest at Fort Worth, l. to r.: Tom Halsey, Alamo Chapter, third prize; Ruth Patterson, Southwestern Section, first prize; Art Vaughn, Panhandle Chapter, second prize.

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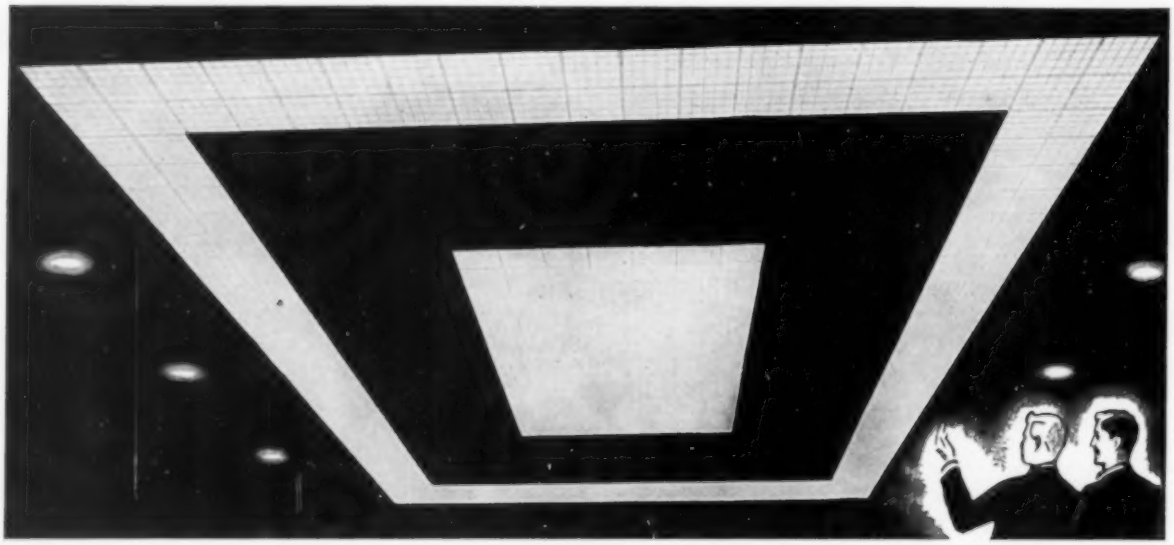

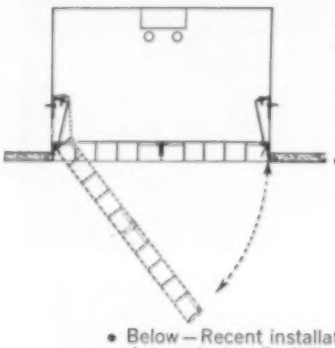

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(Continued from page 10A)

Comfort Vs. Cost for Industrial Lighting — R. D. Bradley, Day-Brite Lighting, Inc., St. Louis, Mo.

DINNER DANCE

Chairman — John E. Metzenthin.

Tuesday, April 10th

Chairman — Paul R. Sheline.
New Developments in Light Sources — W. P. Lowell, Jr., Sylvania Electric Products Inc., Salem, Mass.
Control of Light by Glassware — Edwin R. Hunt, Corning Glass Works, St. Louis, Mo.
Value of Lighting — Richard Kelly, Lighting Designer, New York, N. Y.

LUNCHEON

Chairman — C. R. McCreaken.
Speaker — Rev. Hayden Edwards.

AFTERNOON SESSION

Chairman — Ray H. Bowyer.
Residential Lighting — Harwell Hamilton Harris, Architect, Fort Worth, Texas.
My Most Interesting Lighting Job Contest.

COMMITTEE PERSONNEL

All Sections and Chapters of the Southwestern Region collaborated for the success of the meeting. Specific credit, however, is due the following committee chairmen who had the immediate responsibility:

General Conference Co-Chairmen	L. T. Anderson H. G. Jones
Papers and Program Co-Chairmen	Ruth Patterson John B. Deck, Jr.
Finance	W. T. Kimery
Registration	E. L. Cole
Attendance	Charles F. Shearer
Reception	John L. Healy
Hotel	J. E. Burns
Publicity	J. W. Perry
Ladies Program	Mrs. H. G. Jones Mrs. Joe E. Burns Mrs. L. T. Anderson

SOUTHWESTERN REGIONAL OFFICERS

John G. Felton, Jr. — Regional Vice-President
D. V. Hileman — Chairman, Alamo Chapter
Carlton R. Shepherd — Chairman, Ark-La-Tex Chapter
Paul R. Sheline — Chairman, Central Oklahoma Chapter
Ray H. Bowyer — Chairman, Oil Capitol Section
C. R. McCracken — Chairman, Panhandle Chapter
Edward C. Ober — Chairman, San Jacinto Section
John E. Metzenthin — Chairman, Southwestern Section

Certified Lighting Bureau of R. I. Announces First Contest Winners

Winners of the first electrical contractors' contest on Certified Lighting installations have been announced by the sponsor, the Certified Lighting Bureau of Rhode Island, and the twelve awards presented by Laurance C. Messick, Manager of the National Lighting Bureau, on March 29 in Narragansett.

The three top prize winners were: First, New England Machine and Electric Co., Pawtucket; second, Adel Electric Co., Johnston; and third, Walker Electric Co., Providence.

ARCHITECTURAL students at the University of Cincinnati visit the G-E Lighting Institute at Nela Park. Trip is part of a design competition at the University.

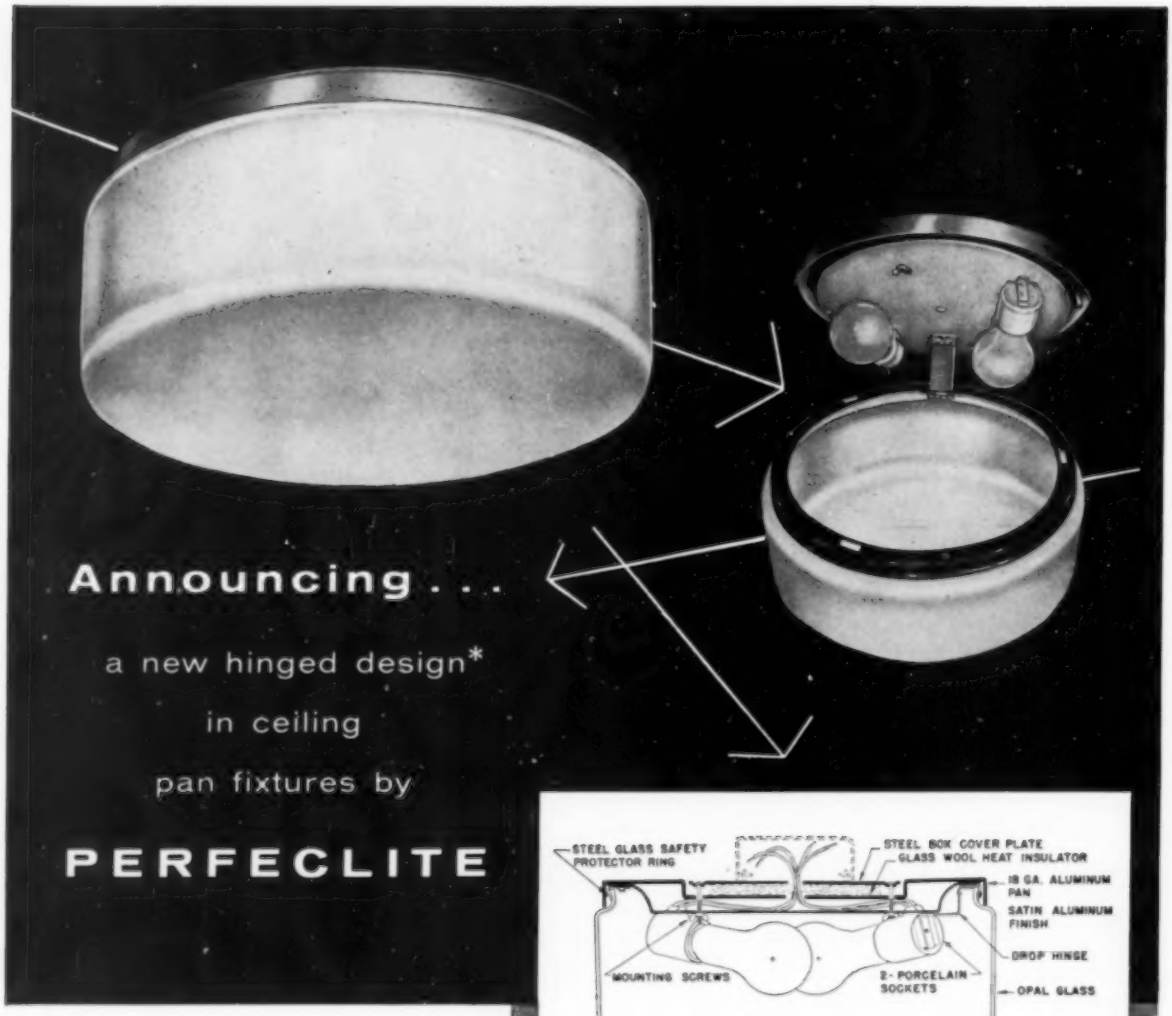
Cincinnati Architectural Students Enter Design Competition

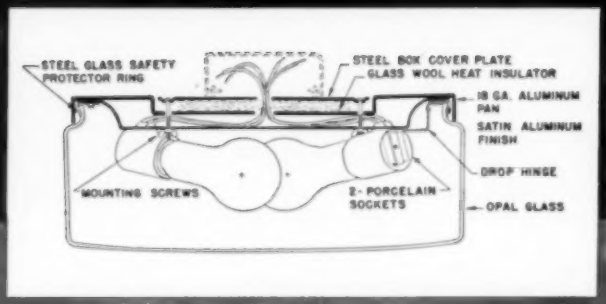
The Ohio Valley Section of I.E.S., is again sponsoring a design competition for architectural students at the University of Cincinnati. This year's problem is "A Jewelry Shop," and construction and exterior design phases have been de-emphasized in favor of the interior lighting for both design and display.

The architectural course operates on an alternate schedule of seven weeks at school and seven weeks in an allied industry. Fitting in with this schedule, the competition was presented in two sections, and two prizes of $25 each are being awarded. Each group has had preliminary instruction in the problem and a trip to the Lighting Institute at the General Electric Co., in Nela Park.

The student trips to Nela Park were arranged by Leonard P. Cohron and Robert W. Brown, who supervised the competition. In charge of the project at the University of Cincinnati were Professors R. W. Dayton and Robert A. Deshon.

PANEL discussion on Architectural Styles and Preferences at the April 19 meeting of the St. Louis Section had Harold W. Rambusch of Rambusch Decorating Co. as Moderator. Panel members Hari Van Hoefen, George Kassabaum, J. D. Murphy and K. E. Wischmeyer are all leading architects in the area. Attendance at the meeting was 179; place was the Cafeteria of the Union Electric Co. Service Building.





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Life of a Regional Vice-President

When Duncan Jones was Junior Vice-President of the Society, and Chairman of the Regional Activities Committee, he wrote a short, illustrated article in Telecast on "Know Your Society — Meet Your Regional Vice-President" (see I.E., March 1953, page 8A). The duties of a Regional Vice-President are so important that it seems appropriate, especially for the benefit of new readers, to describe once more the work of this vital I.E.S. office. Local activities are a pretty important part of the Society operation!

The nation-wide structure of I.E.S., as we all know, is in the geographical Regions. This organizational division was made some years back, for proper representation of all Sections and Chapters at Council meetings. Currently there are ten Regions, though as of October 1, 1956, their number will be eleven. The Southern Region has recently been divided to form two Regions, the Southeastern and the South Central (see I.E., May 1956, page 18A).

Each of these Regions has a Regional Vice-President, elected by vote of the Regional membership for a two-year term. With the possible exception of the President, these men are the busiest in Society activities. They operate at local levels with officers of Sections and Chapters, and take a keen overall interest in the administration of their respective Regions. For this reason, it was decided a few years ago to re-name the Local Activities Committee, more realistically, the Regional Activities Committee. The new name does not imply any less attention to local groups; in fact, the tendency today is for greater cooperation of Sections and Chapters within the Region.

As shown in the accompanying chart, in today's Society the Regional Vice-President is the very "heart" of our operation. This busy man not only gives his all to officers of the local groups, but also serves his "constituency" — individual members and the Region as a whole —as their representative on the National Council. Some of his duties are briefly outlined in the chart and are slightly more detailed as follows:

General Scope

1. Stimulating Society activities and promoting Society expansion.
2. Advising on Regional activities.
3. Guiding local operations.
4. Participating in National affairs and administration.
5. Encouraging intra-Regional relations, such as joint meetings of Sections/Chapters.
6. Serving as liaison between individual membership and overall National administration.

National Duties

Member of Council. He attends the five scheduled meetings of Council each year (or appoints a proxy to attend for him to represent his Region). He presents to Council the prevailing opinions of his Region, and reports to the Section/Chapter officers on important items discussed by Council.

Member of the Regional Activities Committee. The Regional V-P attends the meetings of this Committee (usually full-day sessions on the day before Council). Since Council refers many pertinent matters to this group for resolution, the agenda includes discussions of other than regular Regional problems. Reports of special interest at these meetings are sent to Section/Chapter officers.

Member of the Board of Nomination (National). He participates in the selection of a slate of nominations for national officers.

Regional Duties

Chairman of the Regional Nominating Committee. The Regional V-P meets with the committee annually to select for presentation to the Board of Nomination candidates for national office. Every second year, the committee selects candidates for the new Regional Vice-President.

Ranking Regional Officer at the Regional Conference. In effect the Regional Conference is *his* Conference, conducted under his direction and management. Committees are formed, and personnel approved, as well as dates, places and registration fees. These conferences are so popular that they are now being planned two and three years in advance. Special attention is given to the reception of the President and his wife.

Appointment of Local Representatives. The Regional V-P presents to Council the recommendations of Sections and Chapters for appointment of Local Representatives. These representatives are responsible to the V-P and also work closely with the local officers.

Appointment of Representatives to National Committees. The V-P actively follows the appointment and activities of Section/Chapter representatives on national committees such as Membership, Sustaining Membership, Public Relations and Information, Publication Sales, Data Sheets.

Section/Chapter Budgets. He analyzes these budgets for the ensuing year, giving guidance where necessary. He transmits them to the Finance Committee, and outlines special cases requesting above-formula expenses.

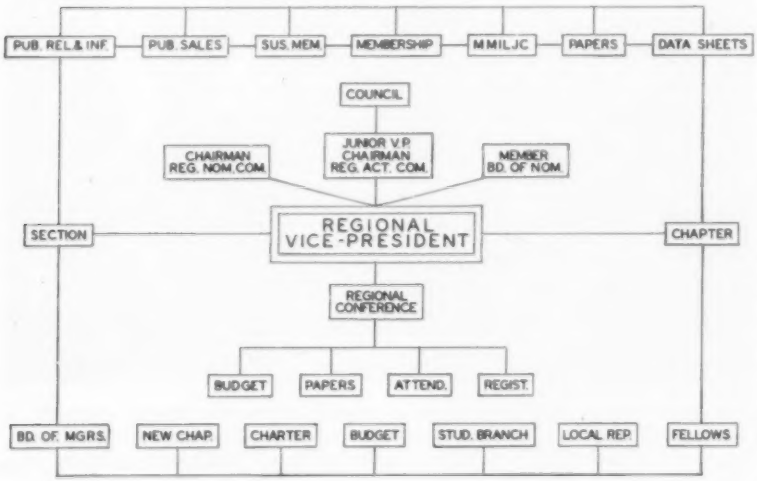
Local Duties

Visits to Sections and Chapters. The Regional V-P tries to visit each local group at a regularly scheduled meeting once a year, or at least once every two years.

Meeting with Local Officers. Discussion of plans and programs with the Section/Chapter Officers are on such topics as:

(a) My Most Interesting Lighting Job Contests.

(*Continued on page* 16A)



(*Continued from page* 15A)

(b) Extension meetings.

(c) Formation of new Chapters and Student Branches. The Regional V-P presents to Council requests for Chapter Charter or Section Charter.

(d) Charter meetings.

(e) Appointment and guidance of committee personnel.

(f) Answering inquiries on all phases of Society operation.

(g) Receiving copies of monthly reports on regular meetings, study clubs, forums, Board of Managers meetings, and expenses.

Bestowing of Honors. The Regional V-P actively follows recommendations for bestowing honors on members where deserved, such as: Fellow, Member Emeritus, nomination for Gold Medal.

Term of Office

The Regional Vice-President must be a full Member or Fellow of the Society. He is nominated by the Regional Nominating Committee and elected by ballot by members of his Region. The two-year terms of the ten Vice-Presidents overlap, with five retiring each year, and the other five beginning the second year of their terms, carrying on their experience and "know-how" in Regional matters.

To list all the duties of the Regional Vice-President would be impossible, as they vary from one Region to another. His correspondence is voluminous, being on the mailing list of most of the 72 Sections and Chapters. He's a mighty busy man and always of one "breed," a mighty fine fellow. GEORGE J. TAYLOR, *General Secretary.*

I.E.S. 50th Anniversary Celebrations Continue

Adding to the list of I.E.S. Sections and Chapters which have celebrated the Golden Anniversary of the Society are the Twin City Section and the Hamilton, Ontario, Chapter, which did so at their April meetings.

Twin City Section's celebration was the occasion of the visit of Regional Vice-President James R. Chambers, who officiated at the cake-cutting. John R. Werket is the lucky member who found the Golden Anniversary pin in his slice of cake and was awarded a check for ten dollars to help him on his way to the National Conference in Boston this September.

Also on the program was the Section's contest for My Most Interesting Lighting Job, which was conducted in a somewhat different format. Entries were judged in categories, and the final winner determined by a sweepstake. Sweepstake winner was Don Greene, in the commercial category, with Richard K. Graf a runner-up with his residential lighting installation. In all, there were three residential entries and nine commercial. The panel of 15 judges was selected from the membership of the Section.

ANNIVERSARY cake is cut by Midwestern Regional V-P Jim Chambers at the Twin City Section's celebration of the IES Golden Anniversary. At right is A. A. Aronson, Vice-Chairman of the Section, who presided at the meeting.

Hamilton, Ontario, Chapter's Anniversary party featured a showing of slides depicting the progress of I.E.S., by Chester Kuzniar, Chapter Chairman. Ed Daines was the recipient of the Anniversary pin, making him the Chapter's representative to the Boston Conference.

The technical session of the program was devoted to school lighting. J. Quist and W. Stafford, of the architectural firm of Prack and Prack, conducted a tour of Hill Park Secondary School, the area's newest high school. After the tour, Mr. Quist, L. Gasson, C. E. Brown and L. Eull, consulting electrical engineers, formed a panel to answer questions on school lighting.

Maritime Conference Offers "Regional" Type Program

Over 80 members and guests at the Maritime Conference, held in Amherst, N. S. on April 27 and 28, enjoyed a program of activities which might well be considered a "Regional Conference."

Panel discussions, technical papers, and social program were provided beginning the evening of April 27 with a

(*Continued on page* 19A)

GOLDEN Anniversary Meeting of the Hamilton Ontario Chapter featured a cake, cut by Chapter Chairman and speakers, l. to r.: Jack Quist, Laurie Gasson, Chairman Chester Kuzniar, Edgar Brown and Lea Eull.

Turn on a big new source of profit from the **new** concept of lighting... LUXTROL!

Make the most of this revolutionary new idea in functional and decorative lighting.

LUXTROL Light Control! A control system which, by just the turn of a dial, creates any level of light from dark to full bright. From full bright to dark.

Practically **everyone** who sees LUXTROL Light Control demonstrated **wants it!**

New LUXTROL is a soundly engineered autotransformer-type unit. Made doubly safe, with both fuse and thermal-overload protection. It controls incandescent, fluorescent or cold-cathode lighting. Operates coolly, efficiently, silently . . . and has the approval of Underwriters' Laboratories.

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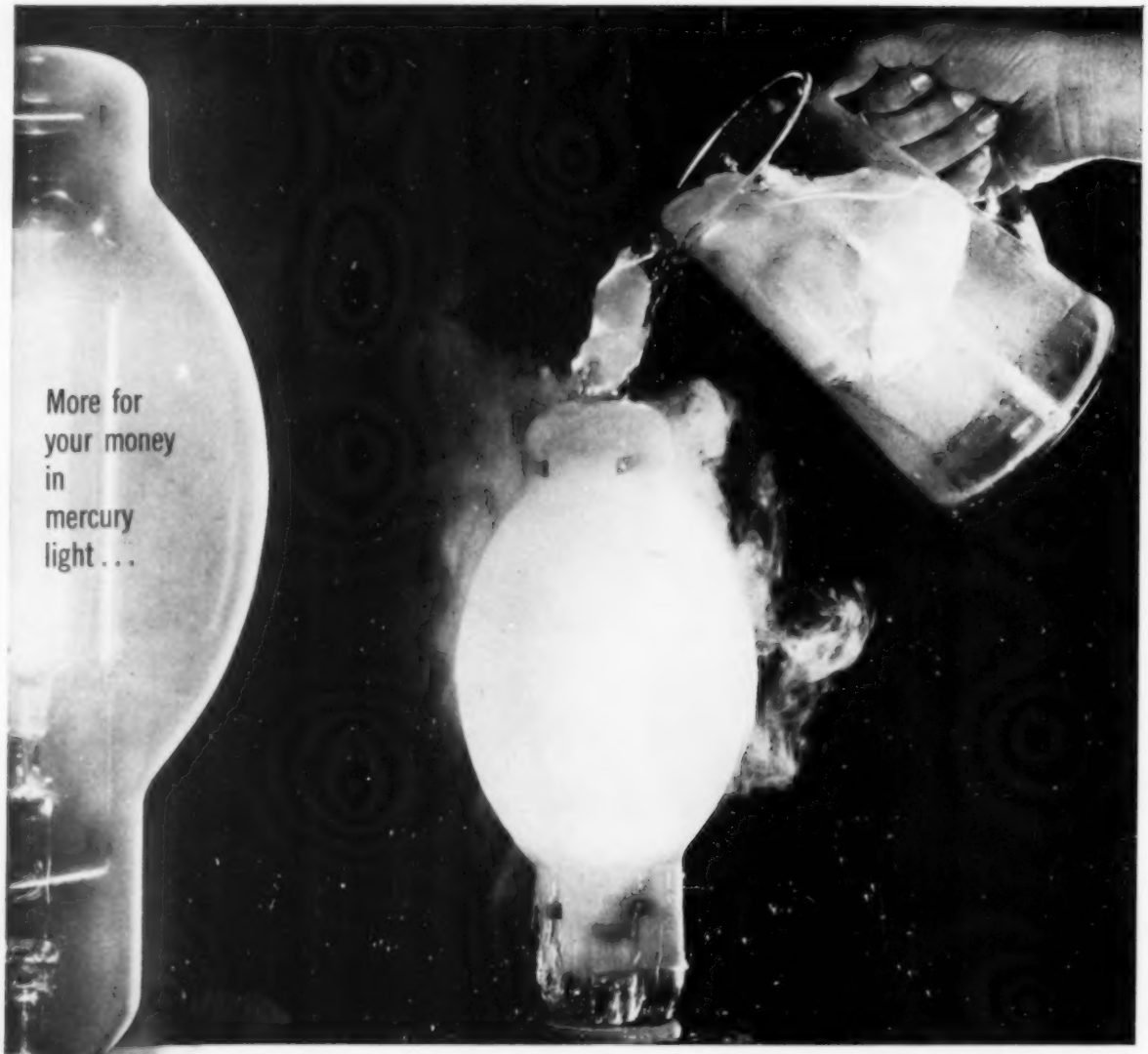


ANNOUNCING NEW WESTINGHOUSE WEATHER DUTY(TM) MERCURY LAMPS

Down again go your lighting costs as Westinghouse announces another basic improvement in high-intensity mercury lamps. It's the world's first line of *weather-resistant*, heavy-duty mercury lamps.

Made with hard, tough, thermally stable glass, new Westinghouse WEATHER DUTY Mercury Lamps can be burned outdoors unprotected in rain, snow or sleet with no risk of cracking. And they can be burned indoors in ventilated fixtures with no danger of shattering under water drops entering through the ventilating openings. Moreover, they are highly resistant to mechanical breakage and to the corrosive effect of industrial fumes.

Thus in any type of installation—indoor or outdoor—Westinghouse WEATHER DUTY Mercury Lamps save you money three new ways. First, by eliminating the need for protective shields and permitting the use of cheaper fixtures. Second, by doing away with costly shield maintenance. And third, by releasing the large amount of light wasted by dirty shields.

WEATHER DUTY Mercury Lamps are the latest example of how Westinghouse gives you "*more for your money in mercury light.*" Now available types E-H1-WD, J-H1-WD, A-H12-WD, C-H12-WD, A-H15-WD and B-H15-WD.

WESTINGHOUSE GUARANTEES the service life of all its widely used types of quartz mercury lamps. For full details call your Westinghouse Lamp Representative—or write Westinghouse Lamp Div., Dept. IE-1, Bloomfield, N. J. "You can be sure if it's Westinghouse."

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU***

MARITIME CONFERENCE was held April 27-28. Left to right are: Ken Wilkinson, Halifax; Ken Martin, Moncton; Ken Stiles, Fredericton; John Morrison, Saint John; George Robinson, Saint John; Henry Lushington, Halifax; and seated, Sifrois LeBlanc, Moncton.

(*Continued from page* 16A)

dinner address by I.E.S. Past President Duncan M. Jones.

The Maritime Chapter and the Bluenose Chapter were joint sponsors of the meeting. The program was as follows:

FRIDAY EVENING

Chairman's Reception—R. S. Dickie, Maritime Chapter Chairman.
Dinner — W. F. McElman, Conference Chairman.
Address — Duncan M. Jones, Past-President, introduced by D. R. Webb.
Entertainment — Saint John, Moncton, Halifax and Fredericton groups.

SATURDAY

Advances in Light Sources—Allan MacDonald, Canadian General Electric, Halifax.
Luncheon—Henry Lushington, Halifax, Chairman.
Speaker—C. Howard Simpkin, Electrical Contractor, Montreal.
My Most Interesting Lighting Job Contest — Sifrois LeBlanc, Moncton, Chairman.
Outdoor Floodlighting — C. A. Albini, Amalgamated Electric Corp., Ltd., Toronto.
Reception — Bluenose Chapter.
Dinner — J. Clary Nickerson, Moncton, Chairman.
Presentation of Awards, MMILJ Contest — by Joseph Thomas, Canadian Regional Vice-President.

The ladies program, arranged by Mrs. Vera McElman, included a sherry party, luncheon and a tour of Mount Allison Art Centre's special exhibition of craft work.

Conference Committee Chairmen were:

Chairman — Wilf McElman.
Registration — Roy Martin.
Program and speakers — George Robinson and Rollie Webb.
MMILJ Contest — Sifrois LeBlanc.
Ladies Program — Vera McElman.

Study Club Host to Section In School Lighting Forum

The Green Bay Study Club of the Milwaukee Section, I.E.S., held a School Lighting Forum on April 19, which constituted the April meeting of the parent Section. Members of the Madison Study Club also attended for a total attendance of 148.

Speakers and subjects at the highly successful forum were:

Lessons Learned in Relighting Minneapolis Schools — Dr. Frederick W. Hill, Assistant Superintendent in Charge of Business Affairs, Minneapolis Public Schools.
The Role of Daylight and Manufactured Light in School Design — Richard F. Hammel, Hammel and Green Architects, St. Paul, Minn.
Some Observations and Cost Studies on Schoolroom Designs Using Natural and Artificial Lighting — L. E. Johnson, Northern States Power Co., Minneapolis, Minn.

The meeting was held at the Wisconsin Public Service Corp. in Green Bay.

Japanese Study Team Visits I.E.S. Headquarters

As part of their nation-wide tour of the United States, under the sponsorship of the International Cooperation Administration, twelve Japanese electrical contractors spent the afternoon at the I.E.S. Headquarters office on March 29. Berlon Cooper, Eastern Editor of *Electrical Construction and Maintenance*, discussed the Society — what it is and how it works — I.E.S. Technical Committees and Recommended Practices; and lighting trends. Milton R. Minto, Vice-President and Treasurer of MacNutt Electric Co., Inc., New York City, spoke on how contractors promote and sell lighting and on installation practices and problems.

(*Continued on page* 20A)

GREEN BAY Study Club was host to the parent Milwaukee Section and the Madison Study Club for the Section's April 19 meeting. Left to right in photo are: B. R. Bunn, Section Chairman; R. R. Cheney, Extension Activities Chairman; Dr. Frederick W. Hill, Richard F. Hammel and Lawrence E. Johnson, guest speakers; A. G. Blitz, Green Bay representative of the Milwaukee Section, and W. H. Unrath, Secretary, Green Bay Study Club.

STUDY TEAM of electrical contractors from Japan visited I.E.S. Headquarters office as part of their New York City program, which was under the direction of Milton R. Minto of MacNutt Electric Co. and Berlon C. Cooper of *Electrical Construction and Maintenance* (at rear in photo) and George M. Powell, Project Manager, International Cooperation Administration (far right).

(Continued from page 19A)

A tour of New York City's new Coliseum followed with a personally conducted inspection of the entire electrical distribution system as well as the lighting.

The group, in their swing around the country has been enjoying the hospitality of many utilities and contracting firms, who have explained their operations. George M. Powell, of I.C.A., is project manager for the trip.

IT SEEMS TO ME

Office Lighting Committee Minority Report

The dissenting Committee members are heartily in favor of the Recommended Practice of Office Lighting published in this issue, and feel that it recognizes advances in the science of illuminating engineering made since 1947, the publication year of the earlier version.

In one regard, the report draws conclusions that are not warranted on the basis of established facts by attempting to define the discomfort effect of direct glare by means of a simple relationship of average fixture brightness to angle of view.

The user of these data should be constantly aware that the proposed method of evaluation has not been accepted by the I.E.S. Committee on Standards of Quality and Quantity for Interior Illumination. The proposed method is only a guide in one direction of evaluation.

Originally, when introduced into the Committee discussion, this so-called Short Cut Method of Discomfort Evaluation was not conceived to create a sharp dividing line, one side of which would render lighting equipment unacceptable.

It was introduced originally as a rule of thumb or approximate guide based on a VCI of 75 per cent (or a glare factor of 25) but then was made more and more stringent so that many installations that have glare ratings more favorable than 25 would not be admissible under the brightness limitation curve in the Recommended Practice.

These comments are published to caution users against strict reliance on the Short Cut Method but, where direct viewing comfort is an important element in the design of an office lighting system, reference should be made to the two comprehensive methods of direct glare evaluation, using either or both as a check in order to take into account all of the elements (of which average luminaire brightness is only one) that affect viewing comfort. GENE G. RAE, *Holophane Co. Inc., New York, N. Y.*

This rebuttal to the above "Minority Report" is offered to prevent possible misunderstandings and erroneous conclusions that might be drawn from the implications of the minority report submitted by committee members G. G. Rae and R. W. Wylie. As Chairman of the Office Lighting Committee, I recognize the right of dissenting members to make their viewpoints known. I believe that it is important, however, that the intent of the disputed recommendations and some of the background leading to them be clearly understood.

The IES Committee on Standards of Quality and Quantity for Interior Illumination has been studying the problem of evaluating the discomfort effect of direct glare for many years. Their studies have included "the two comprehensive systems of direct glare evaluation" referred to in the minority report, and they concluded that neither of these systems nor any of the other systems proposed thus far was acceptable as an IES Standard.

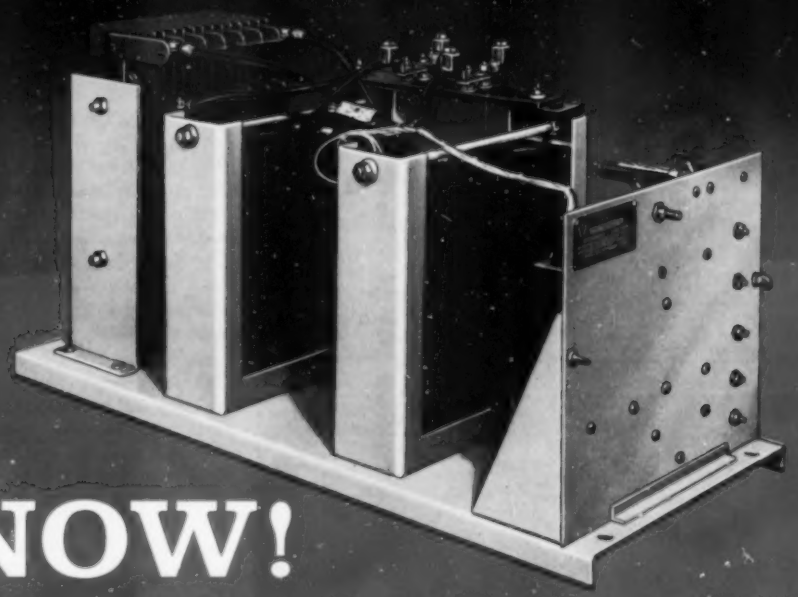
In the absence of an IES Standard, the Office Lighting Committee was advised it was within the Committee's province to use currently available knowledge to develop recommendations that would provide some guidance in the design of comfortable office lighting installations. The Committee recognized that its recommendations should be in a simple form which would permit universal use without requiring special photometric data or laborious calculations. Furthermore, the recommendations should eliminate the possibility of making different assumptions to obtain different answers. Laborious calculations and the opportunity to make different assumptions are among the shortcomings of the "comprehensive methods" which the minority members would have us use.

Extensive studies by the Committee and reviews of current knowledge indicated that with proper environmental conditions, direct glare should not be a problem in large 50-footcandle fluorescent lighting installations if the luminaires had a uniform brightness of 250 footlamberts or less throughout the direct glare zone. These studies took into account the effect of the size, number and positions of luminaires that would be employed for such an installation in a large room. Relatively few luminaires, however, have a uniform brightness distribution, and it was necessary to determine what non-uniform brightness distribution would be equivalent in glare effect to the 250-footlambert uniform brightness.

Luckiesh and Guth showed in Fig. 6 of their 1949 paper (ILLUMINATING ENGINEERING, November 1949) the relative increase in brightness that would result in equal glare effect as a light source is displaced vertically above the line of

(Continued on page 22A)

for better lighting control . . .



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(*Continued from page* 20A)

sight. This represents the maximum non-uniformity in luminaire brightness that would be acceptable and gives us the slope of the sloping line of Fig. 3. Actually, these data appear in the form of an exponential curve when they are plotted on rectangular coordinate paper, so the horizontal coordinate scale was arbitrarily stretched to convert the curve into a straight line. Extensive studies to determine the equivalence of non-uniform sources to uniform sources indicated that the sloping line for non-uniform sources should intersect the 250-footlambert uniform source line at 75°.

The two limiting lines of Fig. 3 obviously represent the extremes of uniformity and non-uniformity, and anything lying between these two extremes should be equally satisfactory. The fact that any number of straight lines can be drawn through 250 footlamberts at 75° and lie between these limiting lines offers the flexibility that is needed in any recommendations for limiting luminaire brightness. In effect, this flexibility means that luminaires having a non-uniform brightness distribution may have somewhat higher brightnesses than those shown by the sloping line at angles above 75° if their effect is offset by considerably lower brightnesses at low angles.

It should be evident from the above that the committee's recommendations are well-founded and recognize the effects of factors other than average brightness. Flexibility has been provided to give the luminaire designer latitude that could not be obtained with a fixed line of demarcation. It is not difficult to design luminaires to satisfy these recommendations, and there are many such luminaires currently available.

If and when the SQQ Committee establishes an IES system of evaluating glare or designing *comfortable* lighting installations, recommended brightness limitations such as those offered in the 1956 IES Recommended Practice for Office Lighting will no longer be needed. Until that time, however, such recommendations are essential for the guidance of those who are interested in preventing annoying direct glare in their lighting installations. JOHN J. NEIDHART, *Chairman, IES Office Lighting Committee.*

WESTERN NEW YORK Section at their March 13 meeting, in Buffalo, which featured the Section's contest for My Most Interesting Lighting Job. Entrants in the contest are shown below. Front row, left to right: Byron Lyth, proxy for W. P. Ackendorf, second prize; F. Brendan Burke, third prize; Bob Herget; and Ed Angiel; back row: Norm Harrington, first prize; Bob Haskell, Neal Jacobus and Dick Klaese.

ABOUT PEOPLE

The appointment of three vice-presidents has been announced by Sylvania Electric Products Inc. **Arthur L. Chapman** has been named Vice-President — Manufacturing, with headquarters in the company's New York City offices. **Dr. Bennett S. Ellefson** has been appointed Vice-President — Engineering and Research; and **Marion E. Pettegrew** has been appointed Vice-President — Tungsten-Chemical and Parts Operations. Mr. Pettegrew will continue to have responsibility for parent company supervision of two wholly-owned subsidiaries, Sylvania Electric of Puerto Rico, Inc., and Produtos Eletricos de Mica Ltda., Brazil.

Appointment of **Robert L. Clark** as Executive Secretary of the National Committee for the Development of Scientists and Engineers has been announced, by James M. Mitchell, Acting Director of the National Science Foundation.

Chris J. Witting, vice-president of Westinghouse Electric Corp. and general manager of all consumer product divisions, has been elected to the Board of Governors of the National Electrical Manufacturers Association.

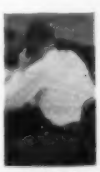
Robert L. Hall, Jr., has been named a Wire and Cable specialist for General Electric's Construction Materials Mid-States district, and will have his office at 215 West Third St., Cincinnati, Ohio.

(*Continued on page* 25A)

SUNBEAM LIGHTING MAKES SMALL OFFICES BIG

Whether it be for an executive's sanctum sanctorum or a busy secretarial office, Sunbeam Lighting Company stands ready to provide the "just right" illumination for a pleasant, friendly atmosphere which lends character and dignity to the private office and work efficiency for all offices.

Look carefully at the Sunbeam lighting installations below which lend a "big" look and a feeling of spaciousness to small offices. See how they help develop the decorative themes, add architectural interest, and provide the kind of quality-engineered illumination on which Sunbeam Lighting has built its proud name. From small offices to large commercial and industrial interiors there's a Sunbeam Visionaire® engineered to meet your most exacting requirements for long-lasting lighting quality, installation simplicity and architectural integrity of design.



Patterned arrangement of Sunbeam DV7700 Series

Continuous rows of recessed H9040 Series with curved Controlenses*

Recessed "large area" HDP3800 Series with molded Plexiglas

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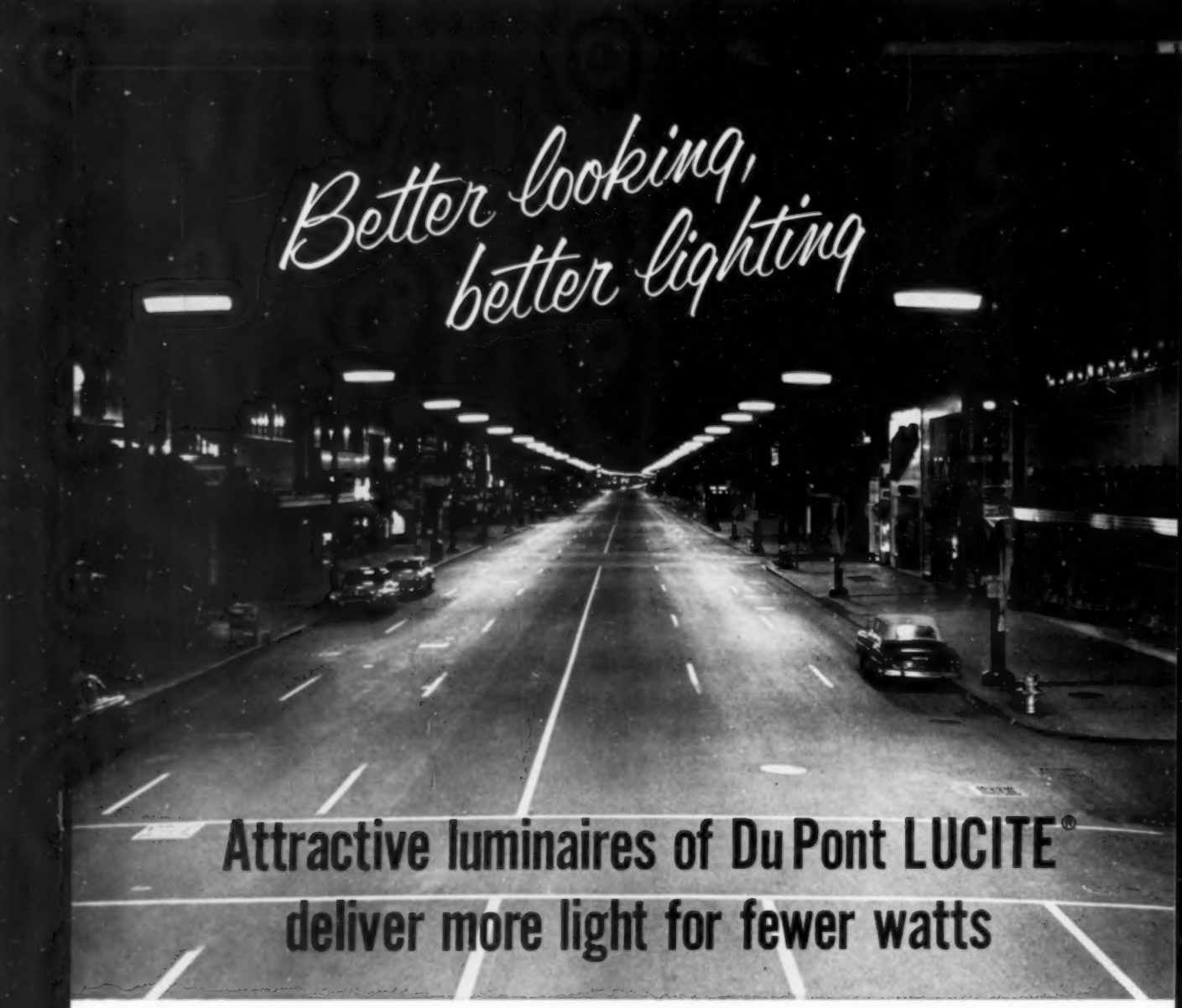

Attractive luminaires of Du Pont LUCITE® deliver more light for fewer watts

These modern luminaires, utilizing LUCITE acrylic resin extruded by Southern Plastics Corporation, Columbia, South Carolina, are bringing more effective lighting to Euclid Avenue in downtown Cleveland . . . and doing so at reduced operating expense.

Fixtures formerly used on Euclid Avenue had two 1,000-watt lamps, dispensing 40,000 lumens. However, because there was a 50 per cent wastage, light on the street was only .7 foot-candles.

With the new luminaires, supplied by Westinghouse Electric Corporation, Cleveland, Ohio, the bulk of the 21,400 lumens from four 100-watt fluorescent tubes is directed downward, giving 1.67 foot-candles of light on the street. The new luminaires at a calculated consumption of only 256,000 kilowatt-hours per year will give more than twice the street illumination of the old lamps, which required 1,024,000 kilowatt-hours per year.

The Euclid Avenue installation represents a total investment of $55,000. The saving effected from lower maintenance and reduced use of electrical energy will amount to about $5,000 annually.

Du Pont LUCITE offers long-lasting beauty, clarity and unique light-transmission properties in all types of modern lighting installations—modular light-diffusing panels, large-area lighting, lenses for troffer and pendant luminaires, side panels and protective elements for outdoor fixtures. For complete information without obligation on how you can profit by including Du Pont LUCITE in your lighting plans, send for the free booklet, "Better Lighting with Du Pont LUCITE". Write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 286, Wilmington 98, Delaware.

• This "Quality Controlled" label may be used only by qualified extruders of Du Pont LUCITE acrylic resin. It assures the lighting industry that the extruded material conforms to standards for low shrinkage and uniform caliper established by E. I. du Pont de Nemours & Co. (Inc.).

Quality Controlled

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BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

WINNERS of the Philadelphia Section's contest for MMILJ were decided at the Section's April 11 meeting. Left to right are: G. W. Wagner, Chairman, Philadelphia Section; Albert H. Lengemann, third prize winner; Miss Elizabeth A. Meehan, first prize; G. C. Linthicum, second prize; and Chairman of the contest committee W. P. Graham.

BOOKS AND PAMPHLETS

Legal Problems in Engineering, by Melvin Nord, published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. 391 pages. $7.50.

This book is said to cover almost every legal subject bearing on engineering, with a view to helping avoid legal action in the first place, and permitting effective collaboration with lawyers should difficulties eventually arise. Legal principles are explained in the text with actual cases presented to exemplify each topic covered. Specific points covered in the book are: contracts, sales, negotiable instruments, insurance, personal property, real property, torts, workmen's compensation, agency, business organizations, municipal corporations, labor law, ethical responsibilities of engineers, professional registration of engineers, construction contracts and specifications, governmental regulations of business, patents, copyrights, trademarks.

The author is a patent attorney and consultant in legal and engineering problems, formerly a professor of chemical engineering at Wayne University.

(Continued from page 22A)

Prescolite Manufacturing Corp., Berkeley, Calif., has appointed **Lawrence C. Papp** and **Edward Sholander** as sales engineers in its Los Angeles office. Mr. Papp was formerly associated with the Lighting Division of Westinghouse Electric Corp. in Oakland, Calif., and Mr. Sholander was a field representative for lighting manufacturers as well as in distributing operations until he joined Prescolite last year.

Metalcraft Products Co., Inc., Philadelphia, announces the appointment of eight representatives. These are: Southeastern New York and Upper New Jersey, **R. W. Auer** & Associates, 400 E. 59th St., New York City, and **I. J. Chesley,** 1919 Westfield Ave., Scotch Plains, N. J. Maryland and Upper Virginia, **C. E. Esposite,** 501 E. Monument St., Baltimore, Md. New England and Albany, N. Y. area, **Simeon Dyer,** 8 Birch Circle, Hingham, Mass. Minnesota, Wisconsin, Nebraska, North and South Dakota, **Russell J. Gerde,** 5649 Grand Ave. S., Minneapolis, Minn. Ohio (except Dayton), West Virginia and Eastern Kentucky, Curtis Sales Corp., 3231 Warrensville Center Road, Shaker Heights, Ohio. Florida, **Frank C. McPherson,** 6417 7th Ave. N., St. Petersburg, Fla. Texas, Arkansas, Oklahoma and Alabama, **Marvin Chenault** & Associates, 202 Prentice Bldg., Dallas, Texas.

The Miller Co., Meriden, Conn., has appointed **Paul A. Crick** as sales representative in the North Texas area, and **Richard J. Slattery** in the Iowa-Nebraska territory. Mr. Crick will have headquarters in Dallas, Texas, and Mr. Slattery in Des Moines, Iowa.

Lawrence A. Wechsler, Jr., has been named Sales Manager, Neon Division of Broadway Maintenance Corp., New York City.

Robert J. Kuzel, Jr., has been added to the staff of the Pittsburgh Reflector Co. offices in Chicago, at 37 S. Wabash Ave. Mr. Kuzel was formerly a commercial lighting engineer with Consumers Power Co., in Jackson, Mich.

Appointment of **D. W. Rice** as product sales manager of the conduit division of National Electric Products Corp. has been announced. Mr. Rice has been in charge of surface raceway sales since joining the company in 1940.

The Edwin F. Guth Co. announces that **Edwin L. Ehret** has recently been appointed to the firm's engineering and technical advisory staff. Mr. Ehret was formerly an illuminating engineer with the Illinois Power Co., district engineer for Westinghouse Lamp Division and for the last eight years has been engaged in lighting fixture manufacturing.

NEW MEMBERS

At the meeting of the I.E.S. Council Executive Committee held at Indianapolis, Indiana, on May 9, 1956, the following were elected to membership. Names marked * are transfers from Associate Member grade.

ALABAMA SECTION

Member:
Deupree, E. M., 2110 Halls Mill Road, Mobile, Ala.

ARK-LA-TEX CHAPTER

Associate Member:
Owsley, W. H., Southwestern Gas & Electric Co., Mt. Pleasant, Texas.

BLUENOSE CHAPTER

Associate Members:
Bryant, John, Bryant Electric Co., Halifax, N. S.
Smith, E. J., Marlite Co. Ltd., Halifax, N. S.
Theakston, D. S., Canadian Broadcasting Corp., Halifax, N. S.

BRITISH COLUMBIA SECTION

Associate Member:
Butler, W. J., B. C. Electric Co. Ltd., Vancouver, B. C.

CAPITAL SECTION

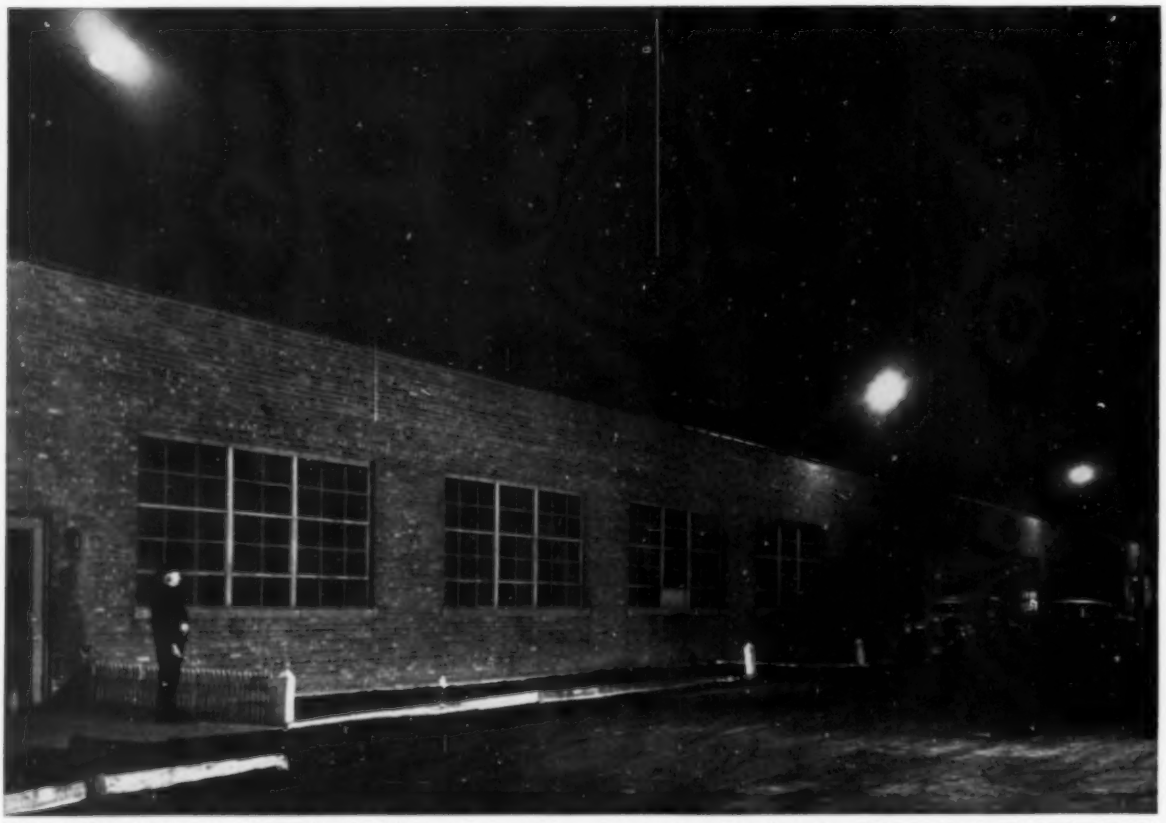
Associate Member:
Toal, V. J., Lee Kendrick & Associates, Arlington, Va.

CENTRAL NEW YORK SECTION

Member:
*Jani, R. W., Corning Glass Works, Corning, N. Y.

Associate Members:
Kolarz, Raymond, Niagara Mohawk Power Corp., Watertown, N. Y.
Wyland, G. B., Gordon B. Wyland Inc., Oneida, N. Y.

(Continued on page 40A)



PLANT PROTECTION *through reliably-maintained light output is assured by Sola Constant Wattage Mercury Vapor Lamp Transformers. Lamps stay lit even when line voltage dips as low as 75v on a 115v line, eliminating jeopardous blackout periods that often exist until lamps are restruck.*

Sola Constant Wattage Transformers Assure Dependable Operation of Outdoor Mercury Vapor Lighting

Sola Mercury Vapor Lamp Transformers offer superior performance, reliability, and reduced system maintenance cost to the expanding market for outdoor mercury vapor lighting. The famous constant wattage principle they employ provides many specific operating advantages. Included are:

- No extinguishing on line voltage dips . . . outages due to line voltage drops are virtually eliminated . . . primary voltage on a 115v line must drop below 75v before lamp extinguishes.
- Regulated lamp wattage and light output . . . energy to lamp is stabilized within $\pm 2\%$ in spite of line voltage swings as great as $\pm 13\%$.
- Open and short circuit protection . . . primary current positively limited under abnormal operating conditions of lamp failure, or external short circuit . . . permits safe use of more lamps per circuit . . . CW circuit eliminates any lamp electrode rectification.
- Extended lamp life . . . regulated voltage, current, and wattage permit continuous stable operation resulting in superior lamp life.

Next time you're concerned with design, specification, or installation of outdoor mercury vapor lighting — shopping centers, parking lots, service stations, playfields, plant area protection—investigate the advantages of Sola Constant Wattage Mercury Vapor Lamp Transformers. Your Sola representative is one of a nationwide organization maintained to provide prompt attention to your requirements.

SOLA *Mercury Vapor Lamp* **TRANSFORMERS**

Write for Bulletin 37-MV-219

SOLA ELECTRIC CO.
4633 West 16th Street
Chicago 50, Illinois

CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464* • *PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988* • *BOSTON: 272 Centre Street, Newton 58, Mass., Bigelow 4-3354* • *CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400* • *KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382* • *LOS ANGELES 23: 3138 E. Olympic Blvd., ANgelus 9-9431* • *TORONTO 17, ONTARIO: 102 Laird Drive, Mayfair 4554* • *Representatives in Other Principal Cities*

THE LIGHTING SYSTEM THAT
goes together on the floor

...and saves 50% on Installation costs

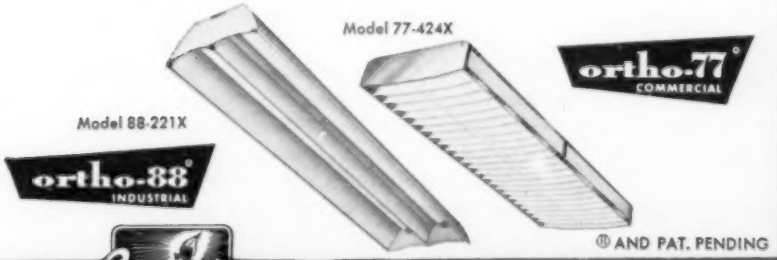
The new Gibson ORTHO Fixtures mount on a special channel called the UNI-RACE. In the photo above, the telescoping sections of the UNI-RACE are being assembled on the floor in a matter of minutes. The receptacles which come with each 4-foot section are connected as shown in the inset. The light but rigid UNI-RACE in 24′ to 48′ lengths is easily lifted and hung directly on joists, beams or stems. The fixtures simply snap into place on the UNI-RACE which holds them in perfect alignment.

An easier, faster and far better job! Is it any wonder that contractors report savings of more than 50% in labor and materials on Gibson ORTHO Installations?

Wouldn't you like more information about this totally new concept in industrial and commercial lighting design? Drop us a line today. We'll send you the whole story.

SNAP—IT'S UP • Connection is made through a built-in plug in the fixture which engages the receptacle in the UNI-RACE. Any fixture may be put up or taken down at will without interrupting other fixtures on the circuit.

VARIABLE SPACING • ORTHO units may be mounted in continuous rows or spaced at intervals of 4, 8, 12 or more feet. Fixtures may be added, removed and rearranged any time by one man without tools.



® AND PAT. PENDING

Gibson LIGHTING

GIBSON Manufacturing Co.

1919 Piedmont Circle, N.E., Atlanta 5, Georgia

You can stop this costly confusion!

Here's a maintenance man with a serious problem. His job—replace a defective lamp in a lighting fixture equipped with a series slimline ballast. One lamp has burned out causing the other to burn dimly or go out completely. But which is the defective lamp—shall he guess or test. Either way, your customers lose time and money from his confusion.

You can stop this unnecessary waste by specifying Westinghouse slimline *lead-lag* ballast—when one lamp burns out the other lamp is not affected. Maintenance men know at a glance which lamp to replace. They can perform their jobs quickly and efficiently without throwing out good lamps.

And you get an extra plus with Westinghouse slimline *lead-lag* ballasts.

The exclusive UI core design means cooler, quieter, and more efficient operation. For complete details about this unique ballast, see your Westinghouse representative. Or write Westinghouse Electric Corporation, Lighting Division, Edgewater Park, Cleveland, Ohio. J-04400

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU***

highest quality plastic extrusions

increase the sales appeal of your products.

They practically pay for themselves through increased quality and improved appearance. You save time and trouble in processing and assembly without cost increase.

KSH Extrusions are consistently uniform in color, size and shape. They pass your most rigid standards.

KSH PLASTICS . . . you design the shape . . . we extrude it

KSH

SALES OFFICES

KSH PLASTICS, INC. • HIGH RIDGE, MO.

CHICAGO, ILL. • MILWAUKEE, WIS. • INDIANAPOLIS, IND.
DAYTON, OHIO • ATLANTA, GA. • GRAND RAPIDS, MICH.
ST. LOUIS, MO. • RED BANK, N. J. • BOSTON, MASS.

THIS IS THE GARCY Speed-Line® PATENT PENDING SYSTEM

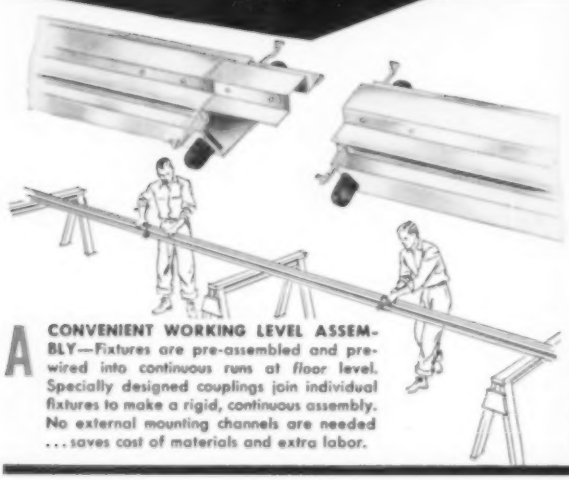
optional at no extra cost with Garcy Visualier and Gar-See-Lite Fixtures

School gets premium lighting at saving of $4482 with GARCY Speed-Line®

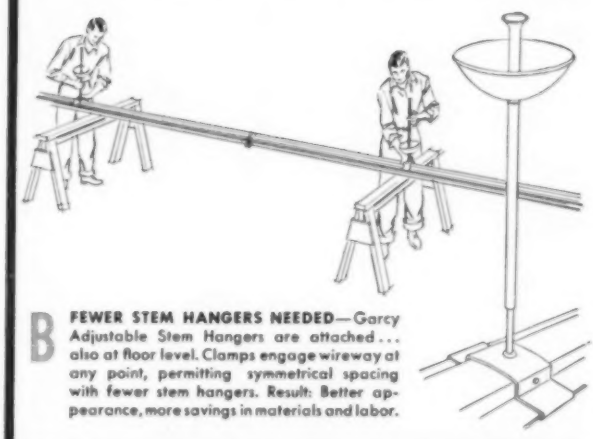
The potential savings of the Garcy *Speed-line* System were well known to E. F. Klingler & Associates, architects, who supervised the job of relighting the Eau Claire Senior High School. All bidders for the lighting contract were invited to submit an alternate figure based on *Speed-line* savings. In the successful bid, *Speed-line* savings were figured at $4482 . . . a cost reduction representing *more than half the installation labor costs*, plus the elimination of external mounting channels. This saving permitted the installation of the finest in school lighting . . . Garcy Visualiers . . . at far less than the cost of ordinary fixtures.

Learn how Speed-line *is reducing installation labor costs . . . in some cases as much as 90% . . . on continuous-run lighting.*

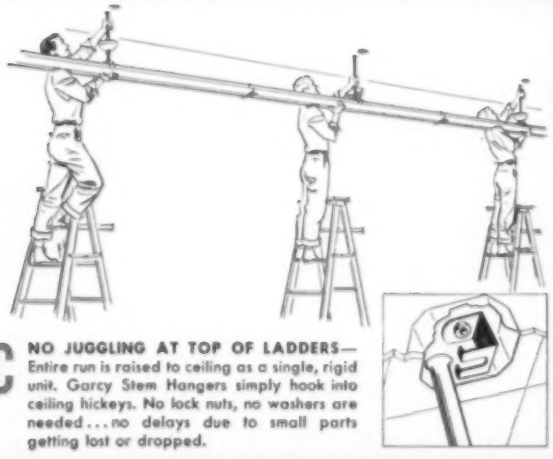
Send today for Bulletin 551-L



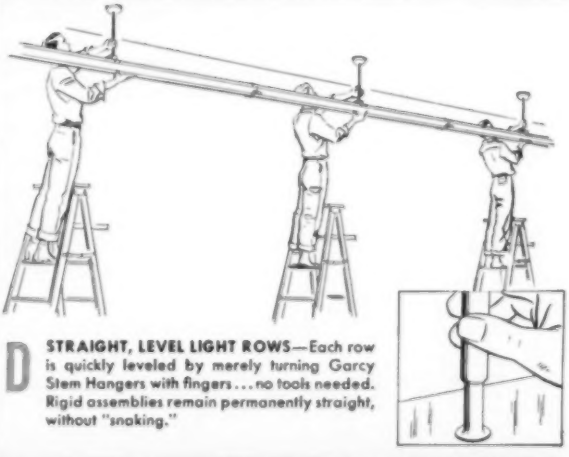
A CONVENIENT WORKING LEVEL ASSEMBLY—Fixtures are pre-assembled and pre-wired into continuous runs at *floor* level. Specially designed couplings join individual fixtures to make a rigid, continuous assembly. No external mounting channels are needed . . . saves cost of materials and extra labor.



B FEWER STEM HANGERS NEEDED—Garcy Adjustable Stem Hangers are attached . . . also at floor level. Clamps engage wireway at any point, permitting symmetrical spacing with fewer stem hangers. Result: Better appearance, more savings in materials and labor.



C NO JUGGLING AT TOP OF LADDERS—Entire run is raised to ceiling as a single, rigid unit. Garcy Stem Hangers simply hook into ceiling hickeys. No lock nuts, no washers are needed . . . no delays due to small parts getting lost or dropped.



D STRAIGHT, LEVEL LIGHT ROWS—Each row is quickly leveled by merely turning Garcy Stem Hangers with fingers . . . no tools needed. Rigid assemblies remain permanently straight, without "snaking."

Send today for Bulletin 551-L

GARCY *Quality by Design*

GARDEN CITY PLATING & MFG. CO., 1760 N. Ashland Ave., Chicago 22, Ill. In Canada: Garcy Co. of Canada, Ltd., 191 Niagara St., Toronto

LIGHTING FOR ACCENT

. . . with new Downlights by miller!

To create atmosphere and mood, to attract attention, to accent form and color, to provide high light intensities where needed—Miller downlights will help you meet your most challenging lighting assignments. Just added to the popular Miller "Merchandise Line", these downlights are available in a wide variety of the most popular floods and spots, fixed and adjustable, with many fixture types, louvres and lenses. Miller's downlight catalogue belongs at your elbow when planning accent lighting—and many general lighting installations as well. *Send for it today!* Dept. ML-3.

Better Lighting for a Brighter America©

miller
SINCE 1844

THE MILLER COMPANY • GENERAL OFFICES: MERIDEN, CONN. • FACTORIES: UTICA, OHIO—MERIDEN, CONN. • IN CANADA: CURTIS LIGHTING OF CANADA LTD., TORONTO

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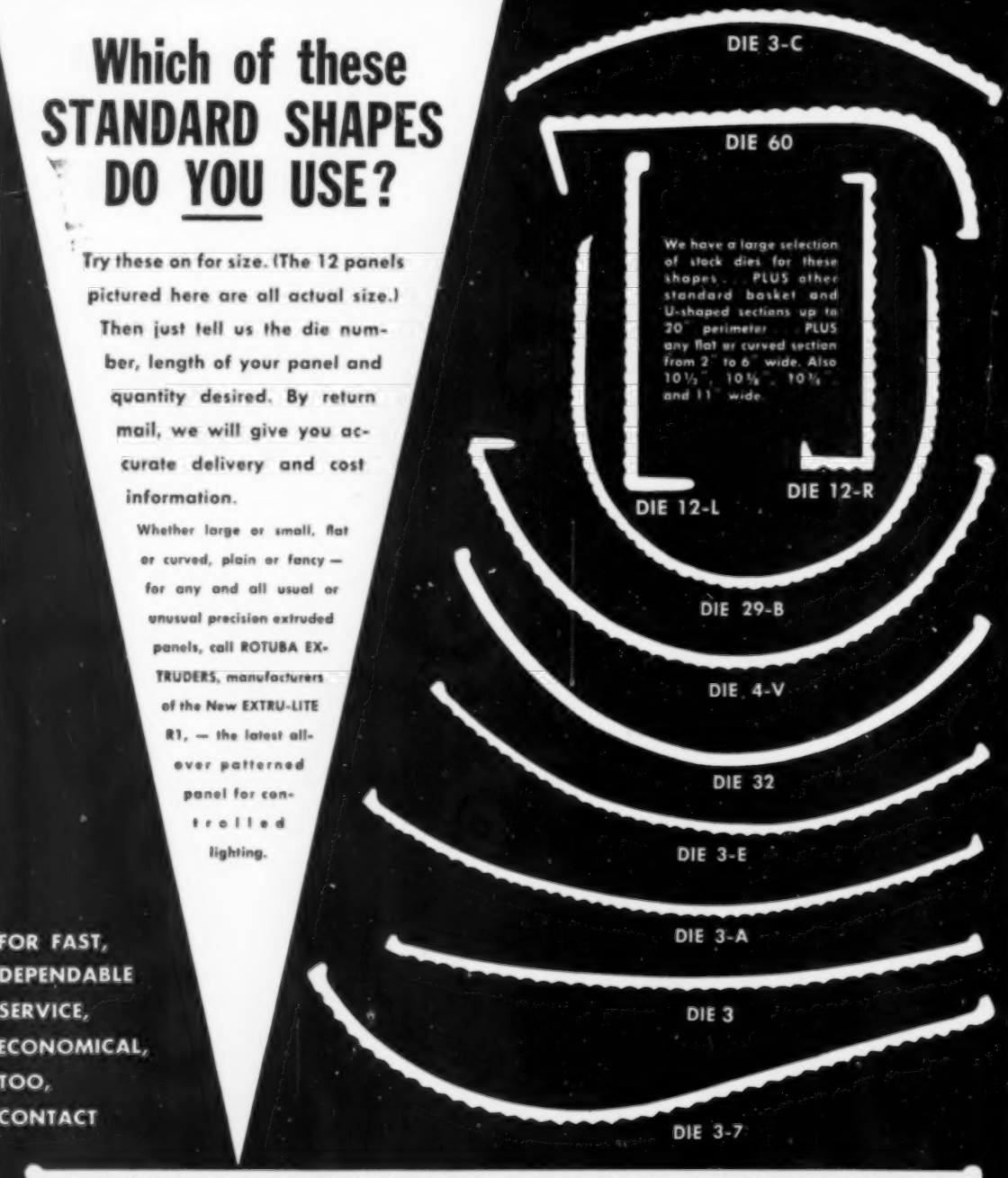
Which of these STANDARD SHAPES DO YOU USE?

Try these on for size. (The 12 panels pictured here are all actual size.) Then just tell us the die number, length of your panel and quantity desired. By return mail, we will give you accurate delivery and cost information.

Whether large or small, flat or curved, plain or fancy — for any and all usual or unusual precision extruded panels, call ROTUBA EXTRUDERS, manufacturers of the New EXTRU-LITE R1, — the latest all-over patterned panel for controlled lighting.

FOR FAST, DEPENDABLE SERVICE, ECONOMICAL, TOO, CONTACT


DIE 3-C
DIE 60
We have a large selection of stock dies for these shapes . . . PLUS other standard basket and U-shaped sections up to 20" perimeter . . . PLUS any flat or curved section from 2" to 6" wide. Also 10½", 10⅝", 10¾" and 11" wide.
DIE 12-L
DIE 12-R
DIE 29-B
DIE 4-V
DIE 32
DIE 3-E
DIE 3-A
DIE 3
DIE 3-7
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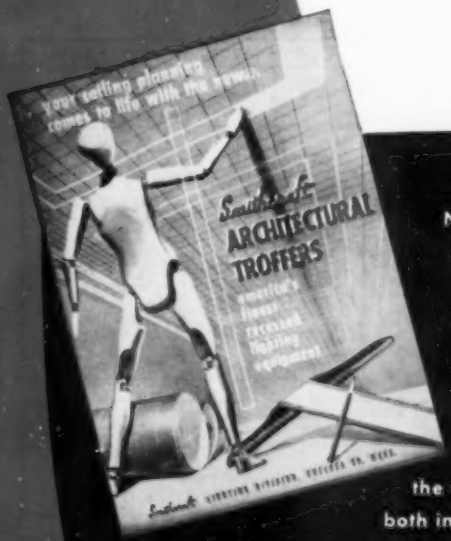
Tel. CHESTNUT HILL 8-1010

appearance IS ONLY half THE STORY!



You'll find the whole story in Smithcraft's "Architectural Troffers" Handbook. Write for your copy today!

*Patent #2,597,875 other patents pending

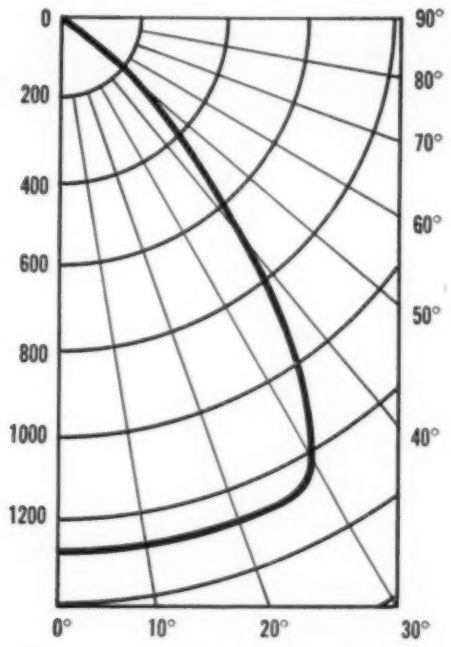
New Smithcraft Architectural Troffers . . . fixtures which assure superlative lighting and clean, trim, uncluttered ceilings. There are no visible catches, latches, hinges, bolts or screws to mar the finished effect . . . and the wide choice of sizes and shielding have made Smithcraft the inevitable choice wherever outstanding appearance is desired.

However, equally important is the other half of the story . . . the exclusive "hidden" features that provide the unlimited versatility, high efficiency and cost-chopping economy in both installation and maintenance. For example, Smithcraft's patented Yoke-Aligner* so effectively simplifies installation that only a screwdriver is needed from start to finish! Developments like these are just as important to the architect and engineer as are Smithcraft's outstanding lighting performance and appearance.

Smithcraft LIGHTING DIVISION, CHELSEA 50, MASS.

AMERICA'S FINEST FLUORESCENT LIGHTING

Prisms are square at edges, become round toward the center. Prisms are effective throughout entire area of lens.



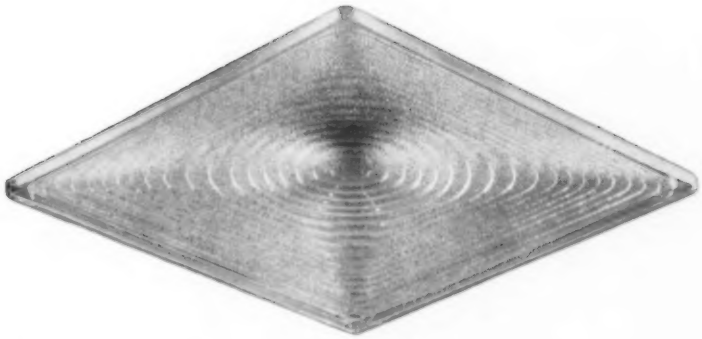
See the uniform light distribution you get with the new Corning Lenslite.

New Corning

CANDLEPOWER DISTRIBUTION DATA			
MID-ZONE ANGLES	MID-ZONE ANGLES	AVG. CANDLE-POWER AT 40 FT.	ZONAL LUMENS
180° zen	90° hor	0	
175°	85°	2	2
165°	75°	15	15
155°	65°	54	53
145°	55°	155	139
135°	45°	396	306
125°	35°	994	619
115°	25°	1292	590
105°	15°	1233	350
95°	5°	1274	120
	0° nadir	1280	

LIGHT FLUX VALUES					
ZONE	LUMENS	PERCENT	ZONE	LUMENS	PERCENT
0°-30°	1060	28.6	0°-90°	2194	59.3
0°-40°	1679	45.4	90°-180°	0	0
0°-60°	2124	57.4	0°-180°	2194	59.3

AVERAGE BRIGHTNESS			
ACROSS AXIS		ALONG AXIS	
ANGLE	Ft-L	ANGLE	Ft-L
85	82	55	962
80	123	50	1363
75	206	45	1992
70	312	40	3060
65	455	35	4314
60	676	30	5080



lenslite gives more even light distribution

improved concave prismatic design for illumination without glare

Whenever you want to use incandescent lighting — for banks, stores, assembly halls—indoors or out—here is a new lens to consider.

Its concave design reduces the visible area of the lens at high angles. With an unusually high efficiency, the lens gets more light to the useful zone. It avoids sharp-angled beams of intense light. It gives illumination without glare.

Because it is made of a heat-resistant glass, you can use the new Corning lenslite indoors or out without fear of thermal shock.

For more information on this new development in Corning Engineered Lightingware write, wire or phone us.

This cross-sectional diagram shows the concave shape of the new Corning lens.

GOLDEN ANNIVERSARY 1906 1956 IES SUSTAINING MEMBER

CORNING GLASS WORKS, 61-6 Crystal Street, **CORNING, N. Y.**

Corning means research in Glass

PRESCOLITE applies aeronautical and automotive diecasting techniques to the lighting industry for STRENGTH, DURABILITY, APPEARANCE!
The fixtures illustrated above, and many others too, employ "DieLux"* die castings as an integral part of the unit. 1. No. 1015-6715 Recessed. 2. No. A-14 Swivel Unit. 3. No. 8585 Hospital Light. 4. No. WB-25 Wall Unit.

*"DieLux"• • • *(PRESCOLITE'S trade name for precision die cast products.)*

Write for your copies of current PRESCOLITE literature.

PRESCOLITE MANUFACTURING CORP., MAIN OFFICE, 2229-4th St., Berkeley 10, California
FACTORIES: Berkeley, California · Neshaminy (Bucks County), Pennsylvania

INTRODUCING...

SYLVANIA'S NEW MOHAWK SERIES

Sylvania Mohawk Series. Available in 2 widths, 2 lengths, 4 types of shielding. (Above) *The Super-Chief*, 23¾" wide; 8-foot-unit with Plastic Louvers shown.

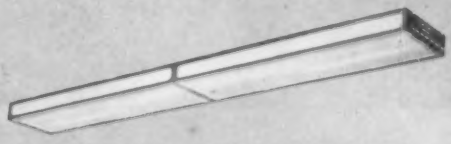
...surface-mounted shallow fixtures for today's low ceilings

Here's a new custom approach to the lighting design problem: the Sylvania *MOHAWK* Fixture Series.

The Mohawk is the most complete fixture line of its type today. It offers you 24 different stylings. This unusual flexibility gives you complete control of the lighting plan. You can mount fixtures individually, in continuous rows, or in your own original pattern. You have a choice of widths, lengths, and number of lamps, as well as four different types of shielding to create the mood you wish.

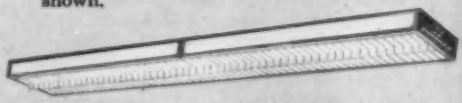
More than this, the Mohawk is one of the shallowest commercial fixtures available—no more than 3¾" from top to bottom. Yet it maintains a high illumination efficiency; delivers a soft, diffused light. In modern low-ceiling rooms, you can now surface-mount attractive and efficient lighting.

This new fixture series contains many designed-in installation and maintenance features. The Sylvania lighting specialist in your area will be glad to talk over and demonstrate this new trend in lighting for schools, offices and stores.



The Chief, 13⅜" wide. 8-foot unit with Corning #70 Low-Brightness Lens shown.

Dished Contour Plastic. Original new shielding design. *Super-Chief* version shown.



Metal Louvers. Available in 13⅜" width units only.

SEND COUPON FOR COMPLETE INFORMATIVE BOOKLET

SYLVANIA®

. . . fastest growing name in sight

LIGHTING • RADIO • ELECTRONICS
TELEVISION • ATOMIC ENERGY

Sylvania Electric Products Inc., Dept. F 30
Lighting Division—Fixtures
One 48th Street, Wheeling, West Virginia

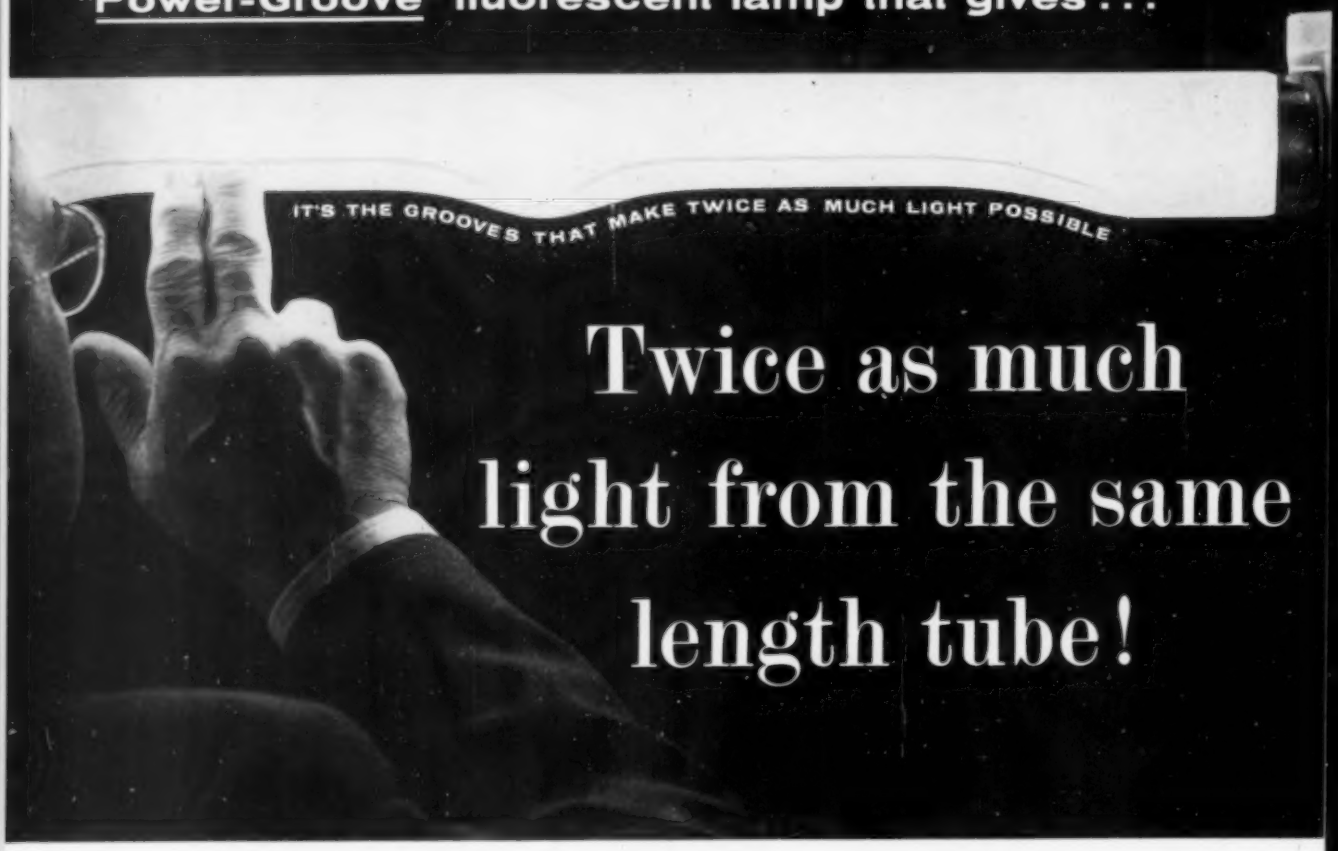
☐ Please send me your informative folder on Sylvania's new *Mohawk* Series.
☐ Have a Sylvania lighting specialist call on me.

Name_____ Title_____

Firm_____ Address_____

City_____ Zone____ State_____

General Electric announces new "Power-Groove" fluorescent lamp that gives . . .



Twice as much light from the same length tube!

New tube design makes G-E "Power-Groove" the most economical fluorescent light source ever developed

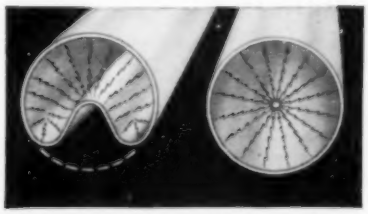
GENERAL ELECTRIC lamp engineers have now developed the new G-E Power-Groove Fluorescent Lamp that gives approximately twice as much light as *any* other fluorescent (and almost three times as much as the 8-foot slimline) with substantially the same efficiency. Now you can get twice the light or more from the same number of lamps—or equal light with half the lamps! Whichever way you use them, you'll save at least 20% in your initial cost of fluorescent lighting . . . and have fewer parts to maintain.

THE POWER-GROOVE LAMPS will be made in the economical 8-foot lengths—approximately 200 watts. They will have double contact recessed bases and will operate on the Rapid Start principle. Four-foot lamps will be available for filling in ends of rows and other special applications. Power-Groove lamps in presently planned sizes will not be interchangeable in any present fluorescent lighting system.

More light at lower cost! *Power-Groove gives a greater increase in light-per-foot than all other combined increases made since G. E. first introduced fluorescent lamps back in 1938!*

OPENS UP NEW USES FOR FLUORESCENTS—G-E Power-Groove lamps will be used extensively for general lighting in stores, offices and industrial plants. Many industrial areas that use filament or mercury lamps can now enjoy the benefits of fluorescent lighting. Besides giving twice as much light, G-E Power-Groove lamps maintain their high light level even at low temperatures, and will therefore, be excellent for outdoor fluorescent lighting.

HOW SOON? By late Fall, General Electric will be producing Power-Groove lamps in quantity—and, at that time, newly-designed fixtures and ballasts are expected to be available. So, if your lighting plans include installations in 1957, plan on new G-E Power-Groove Fluorescent Lamps! For more information, write: General Electric Large Lamp Dept. IE-6, Nela Park, Cleveland 12, Ohio.



COMPARE the new G-E Power-Groove design (left) with ordinary fluorescent lamps. See how the grooves bring the light-producing phosphor coating on the inside wall of the lamp closer to the ultraviolet radiation. Because this energy travels a shorter distance, internal light losses are reduced. It's this radical new design that makes it possible for the G-E Power-Groove to give *twice as much light* with substantially the same efficiency.

Progress Is Our Most Important Product

GENERAL ELECTRIC

PLEXIGLAS

. . . for long-lasting quality in lighting

Styling Building, General Motors Technical Center, Detroit, Michigan. Modular lighting units have 5' x 5' pan type diffusers of PLEXIGLAS acrylic plastic. Architects: Eero Saarinen & Associates; Architects-Engineers: Smith, Hinchman & Grylls Inc.

When lighting systems are based on diffusion through PLEXIGLAS® they have the efficiency, permanence and beauty that add up to illumination of the highest quality. This acrylic plastic provides superior transmission and diffusion of light. It is rigid, strong and durable, with exceptional freedom from discoloration on long exposure to fluorescent lamps. At the General Motors Technical Center, nearly seven acres of PLEXIGLAS attest its advantages as a lighting material. Write for our booklet, "Architectural Lighting with PLEXIGLAS." It shows many of the diffuser shapes and designs that are available from lighting equipment manufacturers.

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

Ask these questions, too, when you judge a fluorescent lamp...

Is it made with Halo Phosphor?

No other phosphors in use today can match Halo Phosphors for maintaining high light output and original color. Westinghouse (and only Westinghouse) uses Halo Phosphors throughout its entire fluorescent lamp line.

Are its electrodes built for longest lamp-life?

Constant development of new and better ways to make fluorescent lamp electrodes has enabled Westinghouse to *triple* the life of its fluorescent lamps since 1948.

Is it easy to seat securely?

Westinghouse fluorescent lamps are built with "guide bumps" on the end-caps. Easily felt with the fingers during lamp installation, they tell at a touch when the lamp has been securely seated in its sockets.

For the full story on how to get more for your money in fluorescent light, contact your Westinghouse Lamp representative. You can be sure . . . if it's Westinghouse.

WATCH WESTINGHOUSE

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU***

(*Continued from page* 25A)

CHICAGO SECTION

Members:
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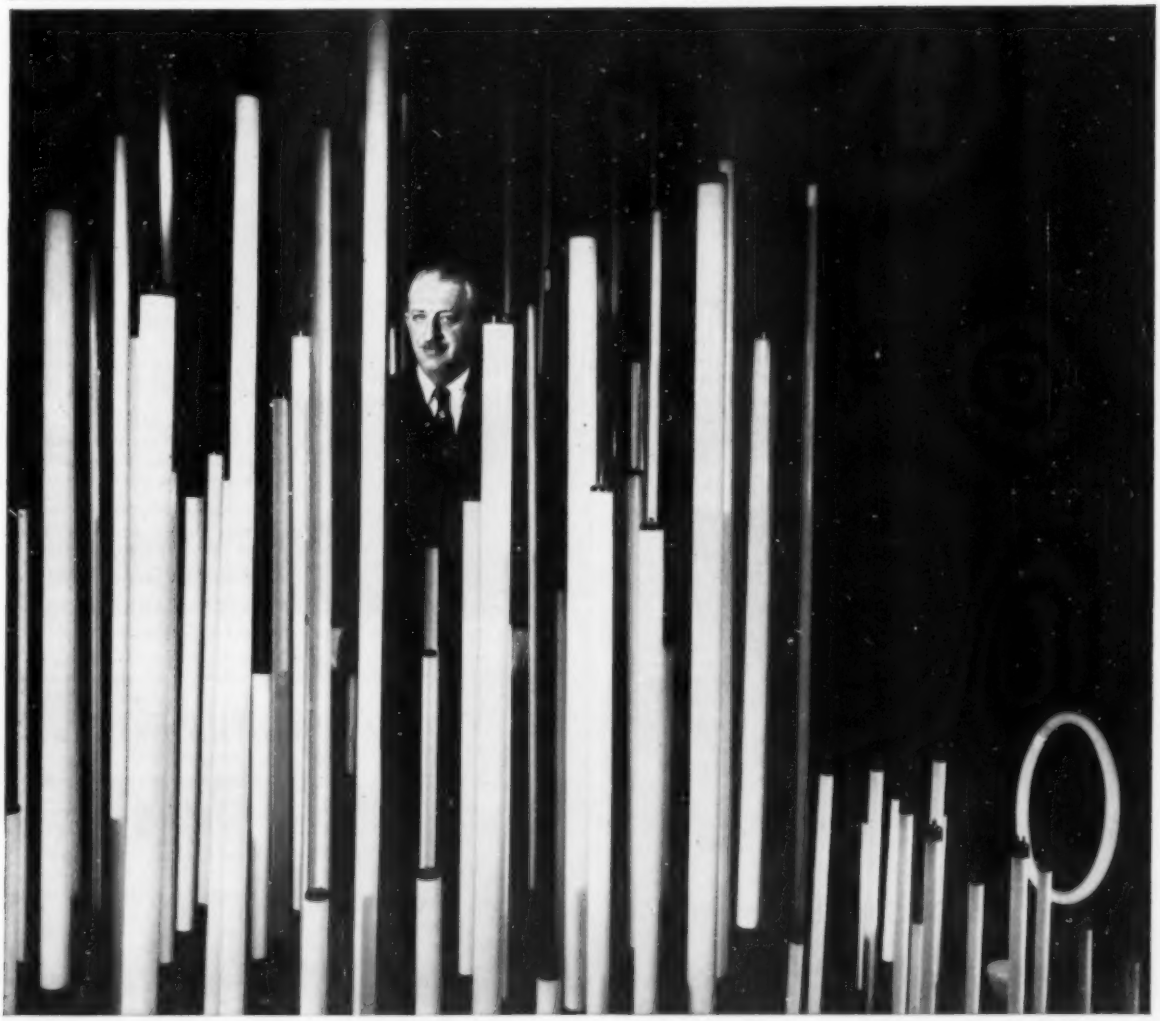

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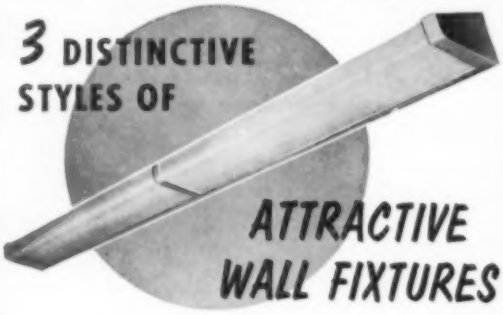

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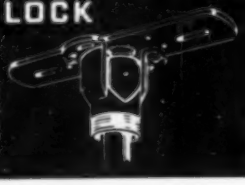

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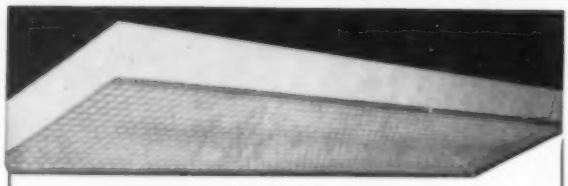

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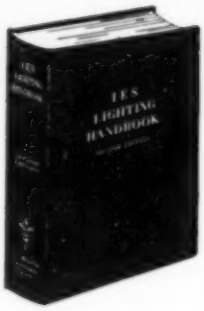

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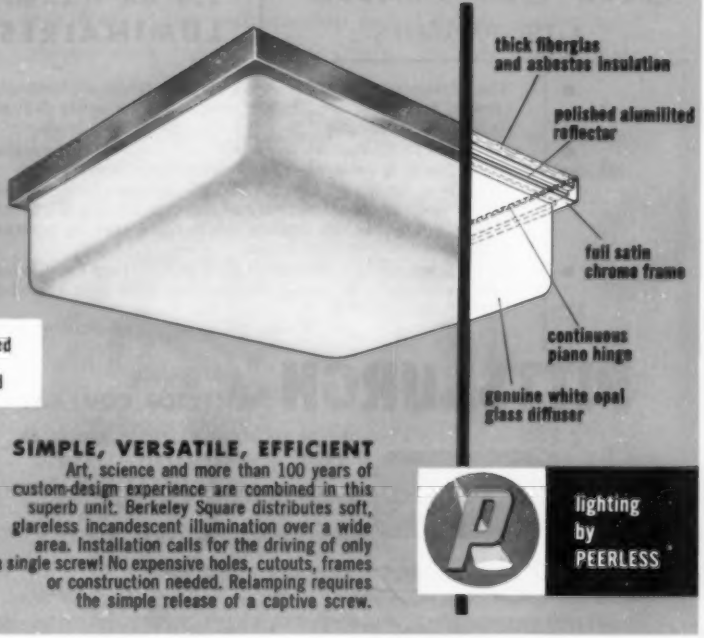
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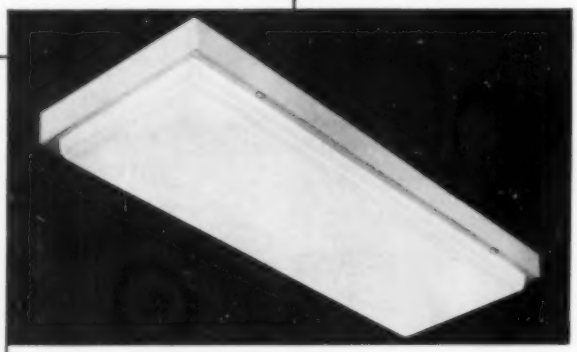

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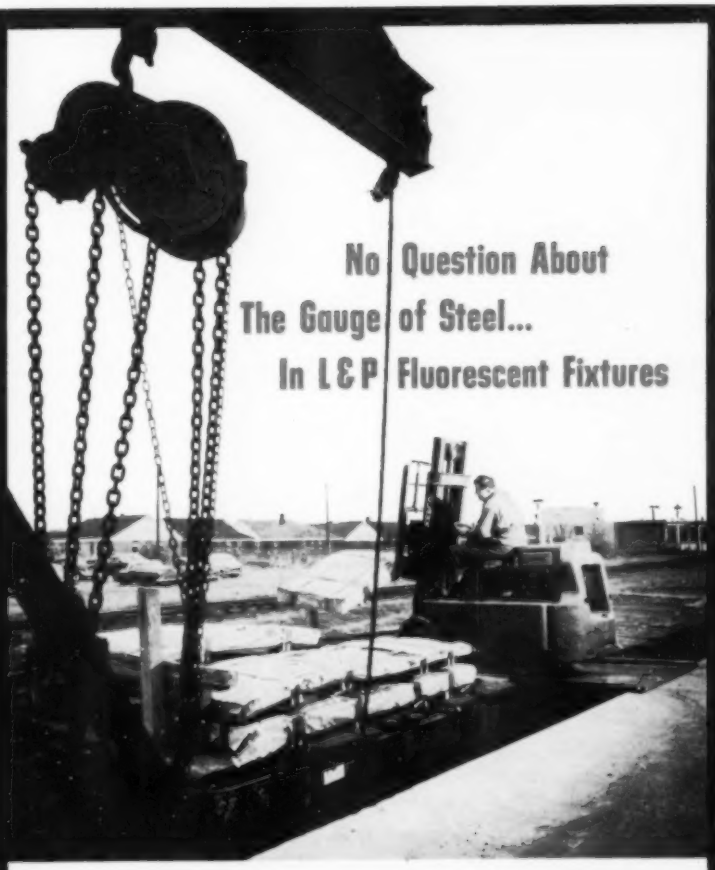

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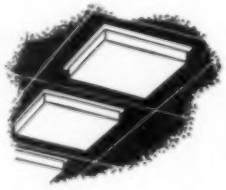

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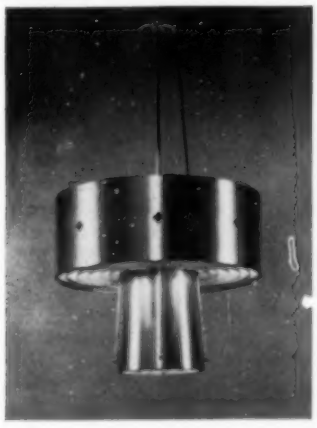

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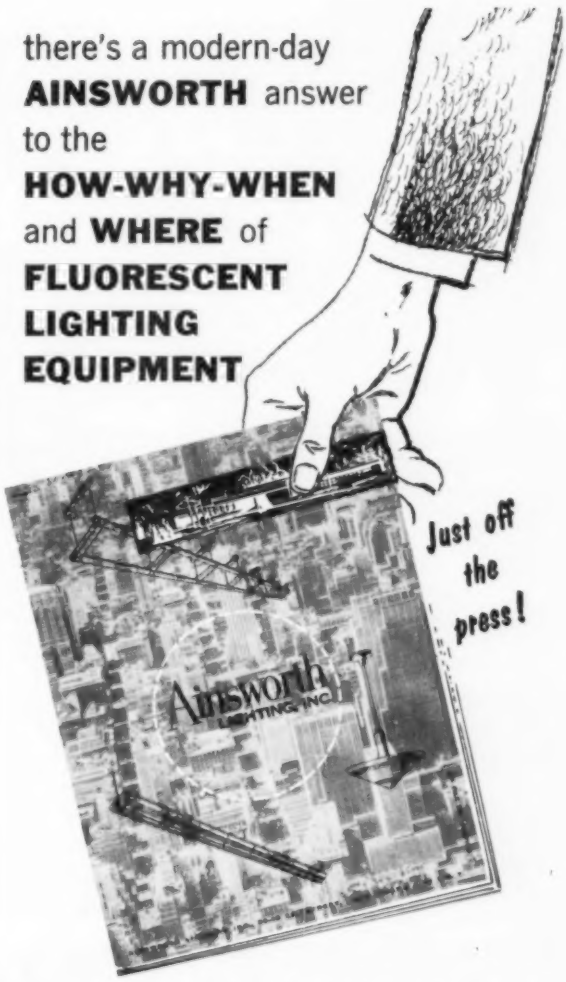

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